Conference Proceedings

May 10-12, 2016
Osaka, Japan

ICEAI
International Congress on Engineering and Information

ICCBES
International Congress on Chemical, Biological and Environmental Sciences
ICEAI
International Congress on Engineering and Information
ISBN 978-986-88450-4-6

ICCBES
International Congress on Chemical, Biological and Environmental Sciences
Content

General Information for Participants ................................................................. 11
International Committees .................................................................................. 13
  International Committee of ICEAI ................................................................. 13
  International Committee of ICCBES .............................................................. 14
Special Thanks to Session Chairs .................................................................... 15
Conference Venue Information ......................................................................... 17
Conference Schedule ......................................................................................... 20
Natural Sciences Keynote Speech (1) ................................................................. 26
Natural Sciences Keynote Speech (2) ................................................................. 28
Oral Sessions ...................................................................................................... 30
  Biological Engineering/ Chemical Engineering .............................................. 30
    ICEAI-1000 .................................................................................................. 31
    ICEAI-1199 .................................................................................................. 33
    ICEAI-1026 .................................................................................................. 35
    ICEAI-1029 .................................................................................................. 37
  Industrial Engineering (1)/ Mechanical Engineering ...................................... 39
    ICEAI-1043 .................................................................................................. 41
    ICEAI-1116 .................................................................................................. 50
    ICEAI-1051 .................................................................................................. 59
    ICEAI-1057 .................................................................................................. 69
    ICEAI-1058 .................................................................................................. 71
    ICEAI-1078 .................................................................................................. 73
  Civil Engineering (1)/ Environmental Sciences (1) ....................................... 81
    ICEAI-1209 .................................................................................................. 83
    ICEAI-1242 .................................................................................................. 85
    ICEAI-1041 .................................................................................................. 87
    ICCBES-1053 .............................................................................................. 97
    ICEAI-930 ................................................................................................... 99
    ICEAI-978 ................................................................................................... 100
  Information Engineering (1)/ Computer Science (1) .................................... 107
    ICEAI-987 .................................................................................................. 109
    ICEAI-988 .................................................................................................. 111
    ICEAI-1001 .................................................................................................. 113
    ICEAI-1015 .................................................................................................. 114
    ICEAI-1038 .................................................................................................. 116
    ICEAI-1189 .................................................................................................. 118
    ICEAI-1230 .................................................................................................. 128
Environmental Sciences (2) .............................................................................. 148
Information Engineering (2) ................................................................. 175
  ICEAI-957 .................................................................................. 177
  ICEAI-1009 ................................................................................ 190
  ICEAI-1061 .................................................................................. 208
  ICEAI-1074 .................................................................................. 216
  ICEAI-1080 .................................................................................. 229
  ICEAI-1087 .................................................................................. 236
Energy Engineering ........................................................................... 237
  ICEAI-1072 .................................................................................. 239
  ICEAI-1175 .................................................................................. 240
  ICEAI-1179 .................................................................................. 251
  ICEAI-1194 .................................................................................. 262
  ICEAI-1221 .................................................................................. 271
  ICEAI-1079 .................................................................................. 273
Environmental Sciences (3)/ Civil Engineering (2) .................................. 280
  ICCBES-1243 ............................................................................... 282
  ICCBES-1252 ............................................................................... 285
  ICCBES-1269 ............................................................................... 287
  ICEAI-1024 .................................................................................. 288
  ICEAI-1190 .................................................................................. 296
  ICEAI-1217 .................................................................................. 297
Information Engineering (3)/ Electrical Engineering (1) ......................... 303
  ICEAI-1172 ............................................................................... 305
  ICEAI-1111 ............................................................................... 315
  ICEAI-1089 ............................................................................... 325
  ICEAI-1008 ............................................................................... 333
  ICEAI-1053 ............................................................................... 346
  ICEAI-1101 ............................................................................... 353
Environmental Sciences (4) ................................................................ 361
  ICCBES-1274 .............................................................................. 363
  ICCBES-1292 .............................................................................. 365
  ICCBES-1301 .............................................................................. 374
  ICCBES-1304 .............................................................................. 376
ICCBES-1332 ...................................................................................... 378
ICCEAI-1191 ...................................................................................... 379
Biological Sciences (1) .......................................................................... 380
ICCBES-1207 ...................................................................................... 383
ICCBES-1326 ...................................................................................... 385
ICCBES-1179 ...................................................................................... 387
ICCBES-1286 ...................................................................................... 394
ICCBES-1209 ...................................................................................... 395
ICCBES-1210 ...................................................................................... 396
Computer Science (2) ........................................................................... 397
ICCEAI-1030 ...................................................................................... 399
ICCEAI-959 ....................................................................................... 402
ICCEAI-1014 ...................................................................................... 415
ICCEAI-1126 ...................................................................................... 428
ICCEAI-954 ....................................................................................... 440
ICCEAI-1208 ...................................................................................... 449
Biological Sciences (2) ......................................................................... 458
ICCBES-1213 ...................................................................................... 460
ICCBES-1295 ...................................................................................... 461
ICCBES-1299 ...................................................................................... 468
ICCBES-1302 ...................................................................................... 476
Electrical Engineering (2) ..................................................................... 490
ICCEAI-1105 ...................................................................................... 492
ICCEAI-1183 ...................................................................................... 505
ICCEAI-1192 ...................................................................................... 507
ICCEAI-1203 ...................................................................................... 515
ICCEAI-1207 ...................................................................................... 527
ICCEAI-1196 ...................................................................................... 534
Biological Sciences (3) ......................................................................... 541
ICCBES-1073 ...................................................................................... 543
ICCBES-1276 ...................................................................................... 545
ICCBES-1317 ...................................................................................... 546
ICCBES-1327 ...................................................................................... 547
ICCBES-1364 ...................................................................................... 557
ICCBES-1115 ...................................................................................... 560
Chemical Sciences (1) ......................................................................... 574
ICCBES-1047 ...................................................................................... 576
ICCBES-1070 ...................................................................................... 577
ICCBES-1084 ...................................................................................... 579
ICCBES-1094........................................................................................................581
ICCBES-1105........................................................................................................582
ICCBES-1244........................................................................................................584
Chemical Sciences (2) / Industrial Engineering (2) / Environmental Sciences (5)
............................................................................................................................585
ICCBES-1239........................................................................................................587
ICCBES-1262........................................................................................................594
ICCBES-1268........................................................................................................596
ICEAI-1035...........................................................................................................604
ICEAI-1229...........................................................................................................611
ICEAI-1202...........................................................................................................621
Civil Engineering (3)..............................................................................................623
ICEAI-1054...........................................................................................................625
ICEAI-1062...........................................................................................................632
ICEAI-1070...........................................................................................................639
ICEAI-1083...........................................................................................................650
ICEAI-1091...........................................................................................................659
Poster Session (1)..................................................................................................672
Chemical Sciences (1) / Electrical Engineering (1).................................................672
ICCBES-1065........................................................................................................678
ICCBES-1081........................................................................................................679
ICCBES-1085........................................................................................................681
ICCBES-1114........................................................................................................685
ICCBES-1123........................................................................................................686
ICCBES-1124........................................................................................................688
ICCBES-1127........................................................................................................690
ICCBES-1128........................................................................................................694
ICCBES-1129........................................................................................................696
ICCBES-1152........................................................................................................698
ICCBES-1157........................................................................................................700
ICCBES-1158........................................................................................................703
ICCBES-1162........................................................................................................706
ICCBES-1165........................................................................................................715
ICCBES-1173........................................................................................................726
ICCBES-1174........................................................................................................729
ICCBES-1175........................................................................................................732
ICCBES-1185........................................................................................................735
ICCBES-1203........................................................................................................738
ICCBES-1204........................................................................................................740
ICCBES-1241..................................................................................742
ICEAI-1059..................................................................................744
ICEAI-1158..................................................................................745
ICCBES-1271..................................................................................746
ICCBES-1288..................................................................................748
ICCBES-1103..................................................................................749
ICEAI-1012..................................................................................750

Poster Session (2) ...........................................................................752
Chemical Sciences (2) / Biological Sciences (1) / Computer Science (1) .... 752
ICCBES-1277..................................................................................758
ICCBES-1281..................................................................................759
ICCBES-1290..................................................................................760
ICCBES-1291..................................................................................762
ICCBES-1314..................................................................................764
ICCBES-1335..................................................................................773
ICCBES-1186..................................................................................775
ICCBES-1121..................................................................................777
ICCBES-1122..................................................................................779
ICCBES-1125..................................................................................781
ICCBES-1126..................................................................................782
ICCBES-1142..................................................................................784
ICCBES-1143..................................................................................787
ICCBES-1147..................................................................................789
ICCBES-1156..................................................................................790
ICCBES-1159..................................................................................791
ICCBES-1166..................................................................................793
ICCBES-1198..................................................................................795
ICCBES-1205..................................................................................797
ICCBES-1215..................................................................................799
ICCBES-1222..................................................................................801
ICCBES-1325..................................................................................803
ICEAI-1086..................................................................................805
ICCBES-1035..................................................................................807
ICCBES-1058..................................................................................809
ICCBES-1076..................................................................................811
ICEAI-1018..................................................................................813

Poster Session (4) ...........................................................................815
Computer Science (2) ......................................................................815
ICEAI-1036..................................................................................817
| ICEAI-1055 | ................................................................. | 819 |
| ICEAI-1067 | ..................................................................... | 830 |
| ICEAI-1071 | ..................................................................... | 839 |
| ICEAI-1081 | ..................................................................... | 851 |
| ICEAI-1090 | ..................................................................... | 854 |
| ICEAI-1104 | ..................................................................... | 857 |
| ICEAI-1115 | ..................................................................... | 865 |
| ICEAI-1166 | ..................................................................... | 872 |
| ICEAI-1184 | ..................................................................... | 883 |
| ICEAI-1016 | ..................................................................... | 895 |
| **Poster Session (5)** | ..................................................................... | 897 |
| **Environmental Sciences/ Energy Engineering** | ..................................................................... | 897 |
| ICCBES-1068 | ..................................................................... | 902 |
| ICCBES-1095 | ..................................................................... | 904 |
| ICCBES-1148 | ..................................................................... | 906 |
| ICCBES-1177 | ..................................................................... | 908 |
| ICCBES-1183 | ..................................................................... | 911 |
| ICCBES-1188 | ..................................................................... | 926 |
| ICCBES-1189 | ..................................................................... | 929 |
| ICCBES-1220 | ..................................................................... | 932 |
| ICCBES-1228 | ..................................................................... | 935 |
| ICCBES-1240 | ..................................................................... | 937 |
| ICCBES-1255 | ..................................................................... | 943 |
| ICCBES-1259 | ..................................................................... | 944 |
| ICCBES-1287 | ..................................................................... | 946 |
| ICCBES-1333 | ..................................................................... | 956 |
| ICCBES-1334 | ..................................................................... | 957 |
| ICCBES-1297 | ..................................................................... | 959 |
| ICEAI-1103 | ..................................................................... | 960 |
| ICEAI-838 | ..................................................................... | 972 |
| ICEAI-989 | ..................................................................... | 975 |
| ICEAI-1164 | ..................................................................... | 983 |
| ICEAI-1182 | ..................................................................... | 986 |
| ICEAI-1218 | ..................................................................... | 990 |
| ICEAI-1225 | ..................................................................... | 1002 |
| ICEAI-1232 | ..................................................................... | 1011 |
| **Poster Session (6)** | ..................................................................... | 1012 |
| **Information Engineering/ Electrical Engineering (2)/ Industrial Engineering/ Civil Engineering/ Mechanical Engineering** | ..................................................................... | 1012 |
General Information for Participants

- Registration
The registration desk will be situated on the 10th Floor at the Osaka International Convention Center during the following time:
13:00-16:30 Tuesday, May 10, 2016
08:00-17:30 Wednesday, May 11, 2016
08:30-16:00 Thursday, May 12, 2016

- Organizer
Higher Education Forum (HEF)
Tel: + 886 2 2740 1498 | www.prohef.org

- A Polite Request to All Participants
Participants are requested to arrive in a timely fashion for all addresses. Presenters are reminded that the time slots should be divided fairly and equally by the number of presentations, and that they should not overrun. The session chair is asked to assume this timekeeping role and to summarize key issues in each topic.

- Certificate
Certificate of Presentation or Certificate of Attendance
A certificate of attendance includes participant's name and affiliation, certifying the participation in the conference. A certificate of presentation indicates a presenter's name, affiliation and the paper title that is presented in the scheduled session.

Certificate Distribution
Oral presenters will receive a certificate of presentation from the session chair after their presentations or at the end of the session. Poster presenters will receive a certificate of presentation from the conference staff at the end of their poster session.

The certificate of presentation will not be issued, either at or after the conference, to authors whose papers are registered but not presented. Instead, the certificate of attendance will be provided after the conference.
Preparation for Oral Presentations

All presentation rooms are equipped with a screen, an LCD projector, and a laptop computer installed with Microsoft PowerPoint. You will be able to insert your USB flash drive into the computer and double check your file in PowerPoint. We recommend you to bring two copies of the file in case that one fails. You may also connect your own laptop to the provided projector; however please ensure you have the requisite connector.

Preparation for Poster Presentation

Materials Provided by the Conference Organizer:
1. X-frame display & base fabric canvases (60cm×160cm)
2. Adhesive tapes or binder clips

Materials Prepared by the Presenters:
1. Home-made Poster(s)
2. Material: not limited, can be posted on the canvases
3. Recommended poster size: 60cm*160cm

A 60cm*160cm poster illustrates the research findings.

1. Wider than 60cm (left)
2. Copy of PowerPoint slides in A4 papers (right)
International Committees

International Committee of ICEAI

Aidy b. Ali, Department of Mechanical and manufacturing Engineering, University of Putra Malaysia, MALAYSIA
K.Ananthanarayanan, Department of Civil Engineering, Indian Institute of Technology, INDIA
Ram Prakash Bharti, Department of Chemical Engineering, Indian Institute of Technology Roorkee, INDIA
Henskens, Frans, Faculty of Engineering & Built Environment, University of Newcastle, AUSTRALIA
P K Garg, Indian Institute of Technology, Roorkee, INDIA
M L Kansal, Department of Water Resources Development & Management & Associate Dean of Students Welfare, Indian Institute of Technology Roorkee, INDIA
Kaushik Kumar, Birla Institute of Technology Mesra, RANCHI
Dattaram. B, Department of Metallurgical Engineering and Materials Science, Indian Institute Of Technology, INDIA
Xiaomei Li, School of Materials Science and Engineering, Southeast University, CHINA
S.P. Mehrotra, Department of Materials Science and Engineering, Indian Institute of Technology Kanpur, INDIA
D. P. Mishra, Department of Aerospace Engineering, Indian Institute of Technology, INDIA
Bhaskarwar A.N., Department of Chemical Engineering, Indian Institute of Technology Delhi, INDIA
Ojha, C.S.P., Department of Civil Engineering, IIT of Roorkee, INDIA
Dhaval Patel, Computer Science, National University of Singapore, SINGAPORE
Dianne Cheong Lee Mei, Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, MaALAYSIA
TSE Kam Tim, Department of Civil and Environmental Engineering, The Hong Kong University of Science and Technology, HONG KONG
N. Balasubramanian, Department of Chemical Engineering, A.C. Tech Campus, Anna University, INDIA
Selim Hossain, School of Engineering and Information Technology, University of New South Wales, AUSTRALIA
Nor Shahniza Kamal Bashah, Department of Computer Technology and Networking, Universiti Teknologi MARA, MALAYSIA
Sanjeevikumar Padmanaban, NIT Puducherry, India.
International Committee of ICCBES

S. Goswami, Chemical and Polymer Engineering, BIT
Mohd Ali Hashim, Department of Chemical Engineering, University of Malaya
Suresh Gupta, Department of Chemical Engineering, Birla Institute of Technology and Science (BIT)
S. Ramaswamy, Department of Geology, University of Madras
Chiew Yee Meng, Professor in Civil & Environmental Engineering, Nanyang Technological University
Hojae Shim, Department of Civil and Environmental Engineering, University of Macau
M.Lakshmi Narasu, Center for Biotechnology, Institute of Science and Technology
Mohamad Pauzi Zakaria, Faculty of Environmental Studies, Universiti Putra Malaysia
Fasihuddin B Ahmad, Faculty of Resource Science & Technology
In Sik Nam, Department of Chemical Engineering, Pohang University of Science and Technology
Chee Kai Chan, Department of Genetics, La Trobe University, Australia
Sanjoy Bandyopadhyay, Department of Chemistry, Indian Institute of Technology Kharagpur,
Lee Keat Teong, School of Chemical Engineering, Universiti Sains Malaysia
Rungtip Soi-ampornkul, Department of Biochemistry, Facultry of Medicine Siriraj hospital, Mahidol University, Thailand
Ramasare Prasad, Department of Biotechnology, Indian Institute of Technology Roorkee
V. K. Gupta, Department of Chemistry, Indian Institute of Technology, Roorkee
M. Rashid, Air Resources Research Laboratory, Universiti Teknologi Malaysia
K. Umamaheswari, Department of Biotechnology, University of Madras
Abdelnaser Omren, Department of Environmental Management and Engineering, Universiti Sains Malaysia
Cosmin Marculescu, Power Engineering Department, Polytechnic University Bucharest
Hamed M. El-Shora, Botany Department, Mansoura University, Egypt
Special Thanks to Session Chairs

Yi-Ting Huang Chung Yuan Christian University
Edward K. Hwang Chung Hua University
Yung-Chih Wang National Central University
Dyah Erny Herwindiati Tarumanagara University
Jin Lo National Dong Hwa University
Josevy Avena Taguibao Mabalacat City College
Wen-Pin Shih National Taiwan University
Kang Won Lee Seoul National University of Science and Technology
Jong Tae Youn Pukyong National University
Subchat Untachai Udonthani Rajabhat University
Jiun-Horng Tsai National Cheng Kung University
Jinwook Jeong Incheon National University
Kevin Oh University of San Francisco
Niwate Arunberkfa Prince of Songkla University
Sedat Yayla Yuzuncu Yil University
Murad Helaleh Anti Doping Lab
Eric Tsun-Tat Wong The Hong Kong Polytechnic University
Masami Yoshida Chiba University
Arisara Seyanont University of the Thai Chamber of Commerce
Xianqiang Tang Changjiang River Scientific Research Institute
Dedi Ruswandi Padjadjaran University
Shu-Chen Wu The Hong Kong Institute of Education
Chih-Hsien Chen National Kaohsiung University of Applied
Yin-Fu Huang National Yunlin University of Science and Technology
Anurug Poeaim King Mongkut’s Institute of Technology Ladkrabang
Edna Luz Raymundo Abulon Philippine Normal University
Chi-Leung Chu National Chiayi University
Yong-Won Song Korea Institute of Science and Technology
Hiroshi Uechi Osaka Gakuin University
Marie Paz Escano Morales Philippine Normal University
Wei-Feng Tung Fu-Jen Catholic University
Miu Ha Kwong Washburn University
Alfred Antony Christy University of Agder
Fu-Gong Lin National Defense Medical Center
Diana Sari Widyatama University
Santosh C Saha University of Mount Union
Chaoyuan Zhu National Chaio-Tung University
Rebecca Lee The University of Hong Kong
Joseph A. McKinney Baylor University
I-Shian (Ivan) Suen Virginia Commonwealth University
Tanakorn Phoo-Ngernkham Rajamangala University of Technology Isan
Jieh-Shian Young National Changhua University of Education
Conference Venue Information

Osaka International Convention Center
Tel: +81-06-4803-5610
Address: 5-3-51 Nakanoshima, Kita-ku, Osaka City, 530-0005 Japan

Access to Osaka International Convention Center
From Kansai International Airport
- Approx. 55 minutes to Osaka Station on the JR Line
- Approx 60 minutes to the Osaka Station by airport limousine bus

15 minutes by Osaka city bus from JR Osaka station. Take No.53-bound for Funatsubashi, or No.55-bound for Tsurumachi 4-chome. Get off at Dojima Ohashi bus stop.

From Osaka International Airport (Itami Airport)
- Approx 30 minutes to Osaka Station by airport bus

15 minutes by Osaka city bus from JR Osaka station. Take No.53-bound for Funatsubashi, or No.55-bound for Tsurumachi 4-chome. Get off at Dojima Ohashi bus stop.

From Shin-Osaka Shinkansen (Bullet Train) Station
- Transfer to the JR local line at Shin-Osaka Station, and disembark at Osaka Station (approx. 5 minutes)

15 minutes by Osaka city bus from JR Osaka station. Take No.53-bound for Funatsubashi, or No.55-bound for Tsurumachi 4-chome. Get off at Dojima Ohashi bus stop.

Train Information
- 1 minute by walk from Nakanoshima station (Exit No.2) on the Keihan line.
- 15 minutes by walk from Fukushima station on the JR loop line
- 10 minutes by walk from Shin-Fukushima station on the JR Tozai line (Exit No.3)
- 10 minutes by walk from Fukushima station on the Hanshin line (Exit No.3)
- 15 minutes by walk from Awaza Station on the Subway Chuo line (Exit No.1), or Sennichimae line (exit No.9).
The 10th Floor Plan

Oral Session: Conference Room 1004~1007
Poster Session: Conference Room 1008
Tea Break & Networking: Conference Room 1008
## Conference Schedule

**Tuesday, May 10, 2016**

### Oral Session (10th Floor)

<table>
<thead>
<tr>
<th>Time</th>
<th>Schedule</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>13:00-16:30</td>
<td>Registration</td>
<td>Foyer Area</td>
</tr>
<tr>
<td>13:30-15:00</td>
<td>Biological Engineering/ Chemical Engineering</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineering (1)</td>
<td>Room 1007</td>
</tr>
<tr>
<td>15:00-15:15</td>
<td><strong>Tea Break &amp; Networking</strong></td>
<td>Room 1008</td>
</tr>
<tr>
<td>15:15-17:15</td>
<td>Civil Engineering (1)/ Environmental Sciences (1)</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Information Engineering (1)/ Computer Science (1)</td>
<td>Room 1007</td>
</tr>
</tbody>
</table>
## Wednesday, May 11, 2016

### Oral Session (10th Floor)

<table>
<thead>
<tr>
<th>Time</th>
<th>Schedule</th>
<th>Venue</th>
</tr>
</thead>
<tbody>
<tr>
<td>08:00-17:30</td>
<td>Registration</td>
<td>Foyer Area</td>
</tr>
<tr>
<td>08:45-10:15</td>
<td>Environmental Sciences (2)</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Information Engineering (2)</td>
<td>Room 1007</td>
</tr>
<tr>
<td>10:15-10:30</td>
<td>Tea Break &amp; Networking</td>
<td>Room 1008</td>
</tr>
<tr>
<td>10:30-12:00</td>
<td><strong>Natural Science Keynote Speech (1):</strong></td>
<td><strong>Room 1006</strong></td>
</tr>
<tr>
<td></td>
<td>Dr. Hooman Farzaneh</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Topic: Sustainable Development and Mitigation in Asian Cities; Challenges and Opportunities</em></td>
<td></td>
</tr>
<tr>
<td>10:30-12:00</td>
<td><strong>Natural Science Keynote Speech (2):</strong></td>
<td><strong>Room 1007</strong></td>
</tr>
<tr>
<td></td>
<td>Dr. Paul C.H. Li.</td>
<td></td>
</tr>
<tr>
<td></td>
<td><em>Topic: The Use of Nanoparticles to Assist Cellular and Nucleic Acid Assays</em></td>
<td></td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch</td>
<td>Conference Hall (12th Floor)</td>
</tr>
<tr>
<td>Time</td>
<td>Session Details</td>
<td>Room</td>
</tr>
<tr>
<td>------------</td>
<td>----------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>13:00-14:30</td>
<td>Energy Engineering</td>
<td>Room 1005</td>
</tr>
<tr>
<td></td>
<td>Environmental Sciences (3)/ Civil Engineering (2)</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Information Engineering (3)/ Electrical Engineering (1)</td>
<td>Room 1007</td>
</tr>
<tr>
<td>14:30-14:45</td>
<td><strong>Tea Break &amp; Networking</strong></td>
<td>Room 1008</td>
</tr>
<tr>
<td>14:45-16:15</td>
<td>Environmental Sciences (4)</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Biological Sciences (1)</td>
<td>Room 1007</td>
</tr>
<tr>
<td>16:15-16:30</td>
<td><strong>Tea Break &amp; Networking</strong></td>
<td>Room 1008</td>
</tr>
<tr>
<td>16:30-18:00</td>
<td>Computer Science (2)</td>
<td>Room 1006</td>
</tr>
<tr>
<td></td>
<td>Biological Sciences (2)</td>
<td>Room 1007</td>
</tr>
</tbody>
</table>
## Wednesday, May 11, 2016
### Poster Session (Room 1008, 10th floor)

<table>
<thead>
<tr>
<th>Time</th>
<th>Schedule</th>
</tr>
</thead>
<tbody>
<tr>
<td>09:30-10:30</td>
<td>Poster Session (1)</td>
</tr>
<tr>
<td></td>
<td>Chemical Sciences (1) / Electrical Engineering (1)</td>
</tr>
<tr>
<td>13:30-14:30</td>
<td>Poster Session (2)</td>
</tr>
<tr>
<td></td>
<td>Chemical Sciences (2) / Biological Sciences (1) / Computer Science (1)</td>
</tr>
<tr>
<td>16:30-17:30</td>
<td>Poster Session (4)</td>
</tr>
<tr>
<td></td>
<td>Computer Science (2)</td>
</tr>
<tr>
<td>Time</td>
<td>Schedule</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------------------------------</td>
</tr>
<tr>
<td>08:30-16:00</td>
<td>Registration</td>
</tr>
<tr>
<td>08:45-10:15</td>
<td>Electrical Engineering (2)</td>
</tr>
<tr>
<td></td>
<td>Biological Sciences (3)</td>
</tr>
<tr>
<td>10:15-10:30</td>
<td>Tea Break &amp; Networking</td>
</tr>
<tr>
<td>10:30-12:00</td>
<td>Chemical Sciences (1)</td>
</tr>
<tr>
<td>12:00-13:00</td>
<td>Lunch</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>13:00-14:30</td>
<td>Chemical Sciences (2)/ Industrial Engineering (2) / Environmental Sciences (5)</td>
</tr>
<tr>
<td>14:30-14:45</td>
<td>Tea Break &amp; Networking</td>
</tr>
<tr>
<td>14:45-16:15</td>
<td>Civil Engineering (3)</td>
</tr>
<tr>
<td>Time</td>
<td>Schedule</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>09:30-10:30</td>
<td>Poster Session (5)</td>
</tr>
<tr>
<td></td>
<td>Environmental Sciences / Energy Engineering</td>
</tr>
<tr>
<td>13:30-14:30</td>
<td>Poster Session (6)</td>
</tr>
<tr>
<td></td>
<td>Information Engineering / Electrical Engineering (2)/</td>
</tr>
<tr>
<td></td>
<td>Industrial Engineering / Civil Engineering / Mechanical Engineering</td>
</tr>
<tr>
<td>15:00-16:00</td>
<td>Poster Session (7)</td>
</tr>
<tr>
<td></td>
<td>Biological Sciences (2)</td>
</tr>
</tbody>
</table>
Topic: Sustainable Development and Mitigation in Asian Cities; Challenges and Opportunities

Hooman Farzaneh
Institute of Advanced Energy
Kyoto University
Japan

Abstract
The world rapidly urbanizing, and a majority of the global population will experience climate change in cities. Cities are being increasingly recognized as major contributors to climate change, consuming two thirds of global primary energy and generating about 71% of energy-related CO2 emissions which is expected to rise to 76% by 2030. The concerns of policy makers dealing with energy in cities focus not only on issues related to availability or its use, but more on its implication after use as it ultimately produces local air pollutants and greenhouse gases as waste which exerts serious local and global implications on human health due to their unacceptable concentrations. The link between the energy sector and climate change mitigation can be possible to study through understanding the main challenges of coming urban energy transitions include: 1) increased urbanization in developing countries, 2) changing infrastructure in developed countries, 3) climate change-energy security imperatives and 4) new technologies at local and grid levels. These challenges highlight the need for cities to reconsider how new urban investments should be prioritized in order to reduce resource consumption and emissions, as well as to achieve local and national development goals. A number of factors influence energy use in and the resulting greenhouse gas (GHG) emissions from cities. The major ones include the urban spatial structure, the nature of transportation systems, income and lifestyle, the energy efficiency of key technologies, industrial processes, building technologies, climate, and waste disposal methods. Implementation of mitigation measures in the energy sector can play an important role in increasing the sufficiency of resources to meet national energy demand at competitive and stable prices and improving the resilience of the energy supply system. Improvements in energy intensity due to positive technological change and switching to low carbon energy systems have played an important role in reducing energy use and associated GHG emissions.
Asian cities, cities in developing nations in particular, must prepare themselves in adopting appropriate adaptation and mitigation strategies/measures through the implementation of a variety of clean energy policies and programs using energy efficiency, renewable energy, reduction of transportation emissions, and other initiatives that can lead to improvements in air quality and public health. The big challenges concerning the clean energy development in Asian cities spring from the lack of awareness at the local government level and the limited institutional capacities and arrangements. Comprehensive policies focused on GHG mitigation do not currently exist at the city level in Asia and only a minority of developed countries such as Japan and Korea have started formulating such policies.

This presentation is based to explore opportunities and challenges for the sustainable development and mitigation in Asian cities. The first part of this presentation deals with the current status of the energy consumption and air pollution in Asian cities. The second part will address in detail the role of executive low carbon policy targets to support the GHG emission and air pollution in selected Asian cities in Japan, China, India, Iran and Indonesia. To this aim, a comprehensive modeling framework based on bottom-up method and the Avoid-Shift-Improve (A-S-I) approach with an analysis and aggregation of cities data will be presented as the most efficient assessment method to quantify the GHG and air pollution mitigation potentials in Asian context. The final part will summerize the opportunities for and the institutional barriers to mainstreaming concerns about GHG emissions and air pollution in Asian cities.

**Brief Introduction of Dr. Hooman Farzaneh**

Dr. Hooman Farzaneh is currently lecturer at the Institute of Advanced Energy, Kyoto University, Japan (since 2015). He has expertise on a broad spectrum of issues related to quantitative and qualitative analysis focusing on developing research patterns of low carbon scenarios and policy implementations designed to tackle air pollution problems in regional and local scales. Before joining Kyoto University, Hooman worked as research fellow at the United Nations University Institute for the Advanced Study of Sustainability, Tokyo, Japan and has been involved in several research projects in relation to sustainable development and mitigation such as climate co-benefits approach in Asian Cities and transfer of low carbon technology to developing countries. Dr. Hooman has previously held positions as a member of the Global Center of Excellence (GCOE) program at Kyoto University (2012-2013) and also assistant professor at Azad University and Sharif Energy Research Institute (SERI) in Tehran, Iran (2007-2012). Born and educated in Iran, Hooman holds a bachelor’s degree in chemical engineering and master’s and PhD degrees in energy system engineering. He has published over 40 journal and conference papers and numerous other reports (both public and confidential).
Natural Sciences Keynote Speech (2)
Room 1007
10:30-12:00  Wednesday  May 11, 2016

Topic:
The Use of Nanoparticles to Assist Cellular and Nucleic Acid Assays

Paul C.H. Li., Ph.D.
Department of Chemistry
Department of Molecular Biology and Biochemistry
Simon Fraser University
Canada

Abstract
Multidrug resistance (MDR) is one of the major obstacles in cancer drug delivery. MDR may be overcome by using MDR inhibitors. Among different classes of these inhibitors, less toxic amphiphilic diblock copolymers composed of methoxypolyethylene glycol-block-poly caprolactone (MePEG-b-PCL) have been studied extensively. Using conventional assays, it was found that the low-molecular-weight diblock copolymer, MePEG17-b-PCL5 (PCL5), enhanced drug accumulation in MDCKII-MDR1 cells. However, when the high-molecular-weight nanoparticles, MePEG114-b-PCL200 (PCL200), were mixed with PCL5 (and the cancer drug) in order to encapsulate them to facilitate drug delivery, there was no drug enhancement effect attributable to PCL5. The reason for this negative result was unclear. Since drug accumulation measured on different cell batches originated from single cells, we employed the microfluidic biochip to conduct the same-single-cell analysis (SASCA) to find out the reason. This analysis allowed us to obtain drug accumulation information faster in comparison to conventional assays. The SASCA results have confirmed that when PCL5 was encapsulated in PCL200 nanoparticles as soon as they were synthesized, the ability of PCL5 to enhance cancer drug accumulation was retained, thus suggesting the PCL200 nanoparticle as a promising delivery system for encapsulating MDR inhibitors, such as PCL5.

In nucleic acid assays, gold nanoparticles (AuNPs) have been used for detection. However, there is a poor fundamental understanding of how gold nanoparticle surfaces influence the DNA hybridization process. Here, we measured the rate constants of the hybridization and dehybridization of DNA on gold nanoparticle surfaces to enable the determination of activation parameters using transition state theory. We show that the target bases need to be detached from the gold nanoparticle surfaces before zipping. This causes a shift of the rate-limiting step of hybridization to the mismatch-sensitive zipping step. Furthermore, our results propose that the binding of gold nanoparticles to the single-stranded DNA segments (commonly known as bubbles) in the duplex DNA stabilizes the bubbles and accelerates the
dehybridization process. We employ the proposed mechanism of DNA hybridization/dehybridization to explain how 5 nm diameter gold nanoparticles help discriminate between single base-pair mismatched DNA molecules, related to the cancer gene KRAS, when performed in a NanoBioArray chip.

**Brief Introduction of Dr. Paul C.H. Li**
Dr. Paul Li obtained his Ph.D in analytical chemistry at the University of Toronto in 1995. Then he developed the microfluidic lab-on-a-chip at the University of Alberta during his postdoctoral work. Dr. Li became assistant professor at City University of Hong Kong in 1996, and then he joined Simon Fraser University in 1999, and he was promoted to full professor in 2010. Dr. Li is interested in integrating microfluidics for single-cell analysis in order to study the transport kinetics of chemical compounds (from herbs) on individual cancer cells. This study is particularly useful for studying multidrug resistant cancer cells, leading to potential improvement in chemotherapy. He is also interested to combine microfluidics with the nucleic acid bioarray for detection of low volume and low concentration of fungal pathogenic DNA, Kras cancer gene DNA, and influenza viral RNA. Dr. Li has other research interests on immunoassay chip, C11 radiotracer synthesis, and F18 enrichment as well. He has published a monograph entitled “Fundamentals of lab on a chip for biological analysis and discovery” in 2010. He is associate editor of Canadian Journal of Pure and Applied Sciences, and sits on the editorial boards of Journal of Proteomics and Genomics, and Hong Kong Pharmaceutical Journal. Dr. Li is the inventor of 4 granted patents and 5 pending patents, and he is the founder and vice president of ZellChip Technologies Inc. specializing in microfluidic-based instruments for life science applications.
Oral Sessions

Biological Engineering/ Chemical Engineering

Tuesday, May 10, 2016  13:30-15:00  Room 1006

Session Chair: Prof. Wen-Pin Shih

ICEAI-1000
A Cloud Structure Rehabilitation Assistant for Articulation Disorder Children
Chang Lin Chen | Ming Chuan University
Chen Yu Lin | Ming Chuan University
Han Yi Ho | Taoyuan General Hospital
Wai Keung Lee | Taoyuan General Hospital
Ying-Hui Lai | Academia Sinica
S.T. Tang | Ming Chuan University

ICEAI-1199
A Study of Relationship between Different Intensity of Pain and EEG Frequency Bands
Chih-Yi Lee | Chung Yuan Christian University
Chia-Yen Yang | Ming Chuan University
Chiung-Cheng Chuang | Chung Yuan Christian University
Huai-Hsiao Chiang | Chung Yuan Christian University

ICEAI-1026
A Method to Measure Natural Frequency of a Spherical Specimen in Liquid Environment by Applying Atomic Force Microscope
Po-Jen Shih | National University of Kaohsiung
Ching-Liang Dai | National Chung Hsing University
Kuang-Wu Chou | National Center for of Research on Earthquake Engineering

ICEAI-1029
Characterization of Protein Binding Force by Utilizing Shear Stress inside Microchannel
Yuh-Chung Hu | National Ilan University
Chi-Yu Chen | National Taiwan University
Horn-Jiunn Sheen | National Taiwan University
Wen-Pin Shih | National Taiwan University
ICEAI-1000
A Cloud Structure Rehabilitation Assistant for Articulation Disorder Children

C.L. Chen\textsuperscript{a}, C.Y. Lin\textsuperscript{a}, H.Y. Ho\textsuperscript{b}, W.K. Lee\textsuperscript{b}, Y.H. Lai\textsuperscript{c} and S.T. Tang\textsuperscript{a}

\textsuperscript{a}Department of Biomedical Engineering, Ming Chuan University, Taoyuan, Taiwan
\textsuperscript{b}Department of Rehabilitation, Taoyuan General Hospital, Ministry of Health and Welfare, Taoyuan, Taiwan
\textsuperscript{c}Research Center for Information Technology Innovation, Academia Sinica, Taipei, Taiwan

1. Background and Objectives
Articulation disorders are common among children and if not treated in a timely manner, they can severely affect learning and daily activities. Speech therapy is highly personalized and time consuming and the effective treatment of articulation disorders may require multiple speech therapists and a rich corpora. An extreme imbalance between the number of available speech therapists and number of children with articulation disorders means that many children are unable to receive the therapy they require. The key to rehabilitation lies in practicing the necessary exercises at home; however, an inability to control the practice conditions means that the effectiveness of therapy is often lacking.

This study combined Android technology with a cloud platform in the construction of a system used in rehabilitation, wherein an Android mobile phone is used in the home during rehabilitation exercises, and the cloud platform records and assesses the results.

2. Methods
Android Studio and JAVA were used to develop the mobile phone app. Smart System Service (S3) of the Institute for Information Industry was used for the cloud platform, and a Xiaomi mobile phone served as the hardware device for the execution of the proposed program. The app includes a login system to preserve patient privacy. The mobile phone provides a built-in microphone and speaker, and a system was devised to monitor background noise. The app can also be used to play and pause the recorded audio files. The S3 cloud platform provides a variety of APIs, including a login system and internal database enabling the uploading, downloading, saving, and deletion of audio files. Therapists can access the database via the login system, listen to the practice session of patients using a customized webpage, provide feedback and suggestions, and record patient progress.

3. Results and Conclusions
Based on the digital files uploaded to the database, therapists can select the appropriate corpora for their patients to practice and personalize practice sessions. The duration, number, and frequency of practices are also stored in the app in the mobile phone to be uploaded to the cloud database. The cloud system and the app are synchronized to keep the database up to date. The app in the mobile phone has a user-friendly interactive interface to generate patient interest in practicing. The system provides pronunciation demonstration videos of therapists displaying the proper mouth shapes and tongue placement to assist patients as they practice by themselves. The cloud platform enables therapists to check in on their patients when needed. They can adjust the practice content based on patient circumstances and remind them to keep practicing, which is the part that current home exercise programs lack most. The rehabilitation process includes hospital rehabilitation and home rehabilitation, which complement each other and are both necessary. Despite the importance of home rehabilitation, it has long been difficult to control its effectiveness. Thus, when rehabilitation results are poor, therapists cannot confirm whether the problem is the content of home practices or inadequate practice. This study resolves this issue and improves the
overall effectiveness of rehabilitation.

Keywords: Articulation disorder, cloud platform, smart phone.
ICEAI-1199
A Study of Relationship between Different Intensity of Pain and EEG Frequency Bands

C.Y. Lee\textsuperscript{a}, C.Y. Yang\textsuperscript{b}, H.H. Chiang\textsuperscript{a}, C.C. Chuang\textsuperscript{a}
\textsuperscript{a}Department of Biomedical Engineering, Chung Yuan Christian University, Taiwan
\textsuperscript{b}Department of Biomedical Engineering, Ming Chuan University, Taiwan

1. Background/ Objectives and Goals

Pain is a subjective first-person experience and is very complex. The clinician is depending on self-report (eg: Visual Analogue Scale, Numerical Rating Scale) to do assessment of pain for patients, and give pain relief treatment based on the Analgesic Ladder by World Health Organization. The strength of painkiller administered is divided into three stages. However, doctors are not able to do accurate pain assessment when the patients have limited ability in expressing themselves, cognitive impairment or unwilling to give actual information. Therefore, to resolve this problem, physiological signals are used to reach objective assessment of pain.

Sensory cortex received a lot of messages that contain the whole process of pain when we feel pain. Thus, it is possible to study pain using brain signals. In previous studies, significant differences in frequency domain of EEG signals was found when the subjects were in pain and no pain. However, the relationship between pain intensity and different EEG frequency bands is not yet explored. Therefore, the purpose of this study is to explore the relationship between different levels of pain and electroencephalography frequency bands.

2. Methods

Experiment recruited young and healthy volunteers, including 3 females and 3 males, one subject had to be excluded because of the EEG signals were disturbed too much. Subjects were enrolled only if the following criteria were met: right-handed, ability to understand the instructions of the study, absence of pain, free from any type of chronic pain that will affect EEG recording. Each subject was seated in a comfortable armchair in a quiet and semi-darkened room. This study used a self-made thermal contact-heat stimulator equipment (the range of temperatures was 37-51˚C) to induce heat pain potential and employed the Numerical-Rating Scale (0-10 points) for pain rating. Heat stimulation were delivered to the medial part of the left forearm. EEG signal were recorded using Neuroscan NuAmps system (sampling rate: 1000 Hz; band reject filter: 60 Hz) together with a 32-Channel Quick-Cap (Compumedics Neuroscan, USA).

The first session was to determine four pain thresholds (none, mild, moderate and severe pain) in the subjects. Following with training session that help subjects to get familiar with the whole process of experiment and to distinguish four different levels of pain. Final session was the formal experiment. EEG signal analysis is performed off-line using MATLAB. Filters were used to separate five frequency bands: Delta (1-4Hz), Theta (4-8Hz), Alpha (8-12Hz), Beta\textsubscript{1} (12-18Hz) and Beta\textsubscript{2} (18-30Hz). Power spectral density were calculated after filtering. Statistical analysis was conducted using the Statistical Package for Social Science software and the nonparametric Friedman test with post-hoc Wilcoxon signed ranks tests were performed to assess significant differences in five frequency bands at varying levels of pain.

3. Expected Results/ Conclusion/ Contribution

The purpose of this study is to find out the relevant frequency band in cases of none and mild pain, mild pain and moderate pain, moderate and severe pain. The result showed that mild pain and moderate pain, moderate and severe pain had significant differences in Theta, Beta and Delta band while no significant differences in bands were found in case of none and mild pain. This may due
to insufficient number of participants and failing to use better signal processing method to eliminate noise (such as Independent Components Analysis) before data analysis. Using these significant different bands as features to classify different levels of pain may help doctors to evaluate patients with Disorders of Consciousness in the future. At the same time, helping to realise analgesic ladder introduced by WHO for the patients and letting these patients to receive suitable treatment.

Keywords: pain intensity, electroencephalography, Frequency Analysis
A Method to Measure Natural Frequency of a Spherical Specimen in Liquid Environment by Applying Atomic Force Microscope

Po-Jen Shih\textsuperscript{a}, Ching-Liang Dai\textsuperscript{b}, Kuang-Wu Chou\textsuperscript{c}

\textsuperscript{a} Department of Civil and Environmental Engineering, National University of Kaohsiung, Taiwan
E-mail address: pjshih@nuk.edu.tw

\textsuperscript{b} Department of Mechanical Engineering, National Chung Hsing University, Taiwan
E-mail address: cldai@dragon.nchu.edu.tw

\textsuperscript{c} National Center for of Research on Earthquake Engineering, Taiwan
E-mail address: kwchou@ncree.narl.org.tw

1. Background

The atomic force microscope (AFM) with potentials of operation in liquid environment is widely used to scan contours of biological specimen. In addition to the contours, some mechanical properties are also measured nowadays. The scalars of the specimen are often much larger than the radius of the AFM tip, and the contact force between the tip and the specimen could be obtained by following the Hertz theory. Thus the mechanical properties, such as Young’s modulus, could be measured. However, it is really hard to measure the Young’s modulus of a specimen whose size is nearly to the radius of the AFM tip. To solve the problem, the authors provide the following method. The AFM has two operation modes: the contact mode and the tapping mode. If we apply the tapping mode tip to tap the specimen and the contact mode tip to “listen” the specimen, thus we can measure the natural frequency of the specimen. Then Young’s modulus of the membrane of the specimen could be obtained by applying a membrane frequency function, which will be provided in this study.

To obtain the natural frequency of the pre-stressed membrane, a fluid-filled spherical shell is the simplest model to study the dynamics of the specimen. Rayleigh firstly solved the problem of axisymmetric vibrations of a fluid in a rigid spherical shell. Extensional axisymmetric vibrations of an elastic spherical shell were first studied by Lamb. These models have provided similar frequency equations, and all of them are functions of wave speeds, densities, and geometric parameters. The effect of fluid pressure is implicit in the wave speeds, and shell pre-stress is not considered. Thus, if the shell is soft and filled with a pressured fluid and that leads to pre-stressing of the shell, the wave speeds for the stretched shell should be modified first. But, it is difficult to obtain the wave speeds of the membrane.

2. Methods

In this study, the authors modified Grinfeld’s bubble theory to simulate the buffer fluid outside and the tissue fluid inside the eyeball, and they also replaced the governing equation of the surface material. Since the oscillations of soap bubble and the membrane have great difference, here the membrane is a tensional surface with shear and bending stiffness and is simulated by the stretched membrane vibration theory. The dynamics outside and inside the spherical membrane are governed by Euler’s equations.
where $t$ is the time component, $v_i$ are the covariant components of the velocity fields, the system implies pressure $p$ is harmonic, and $\rho$ is density. Hence the dynamic equation to be satisfied for every point on the membrane is

$$
\left( \frac{E+T}{12(1-v^2)} \right) \nabla^4 w - T \cdot l \cdot \nabla^2 w - (P^+ - P^-) + \rho \cdot l \cdot \frac{\partial^2 w}{\partial t^2} = 0
$$

(2)

where $w$ is the membrane displacement, $E$ is the value of Young’s modulus, $T$ is the membrane tension, $v$ is the value of Poisson’s ratio of the membrane, $l$ is the thickness of the membrane, $P^+$ and $P^-$ are the pressure outside and inside the membrane. Thus the frequency function is

$$
\omega^2 = \frac{\left( E \cdot l + T \cdot l^3 \cdot l \cdot (l+1)^3 \right)}{12(1-v^2)R^2} + \frac{T \cdot l^2(l+1)^2}{R^2} \frac{l^2(l+1)^2}{[l+1] \rho^+ + l \cdot \rho^- + l(l+1) \rho \cdot l_i}
$$

(3)

in which $\omega$ is the radius frequency and $l$ is the order.

### 3. Conclusion

Under the assumption that the membrane is a perfectly spherical and stretched diaphragm, the authors used wave theories to derive an explicit frequency function and to predict the natural frequencies against membrane tension. Furthermore, the model considers eight significant physical parameters from geometry, material properties, densities, and strength. Thus, these assumptions achieved a frequency function focusing on estimating the interaction between the stretched diaphragm and the internal liquid.

Keywords: AFM, natural frequency, pre-stress membrane, contact mode, tapping mode
ICEAI-1029
Characterization of Protein Binding Force by Utilizing Shear Stress inside Microchannel

Chi-Yu Chen\textsuperscript{a}, Wen-Pin Shih\textsuperscript{a,*}, Yuh-Chung Hu\textsuperscript{b}, Horn-Jiunn Sheen\textsuperscript{c}
\textsuperscript{a}Department of Mechanical Engineering, National Taiwan University, Taiwan
E-mail address: wpshih@ntu.edu.tw
\textsuperscript{b}Department of Mechanical and Electro-Mechanical Engineering, National Ilan University, Taiwan
\textsuperscript{c}Institute of Applied Mechanics, National Taiwan University, Taiwan

1. Background and Objectives
Point-of-care biochip has been of high interest with the growing need of \textit{in vitro} diagnosis. To develop an accurate point-of-care biosensor, the interaction between the protein binding and the microfluidics on the chip should be carefully characterized. This paper aims to develop a characterization approach with an associated model for \textit{in situ} determining the protein binding forces. A typical biochip contains a microfluidic channel, with which blood was delivered into a sensing area through pressure difference by vacuum or capillary force. The shear force generated by fluid could break the binding between proteins, so we measured the binding force between specific bindings and developing a system with high accuracy to investigate different kinds of protein-protein interactions. The method of measuring the interaction force between proteins had been revealed by many literatures. However, most of them used atomic force microscope (AFM) to measure the force. This method of measurement need well-controlled environment. Alternatively, we developed a microfluidic system to measure the binding force between primary antibody and secondary antibody indirectly.

2. Methods
In this paper, the primary antibody (Rabbit IgG) was covalently bonded to carboxylated (-COOH) microbeads. The substrate of the microchannel was deposited with a film of polymer containing NHS-ester functional group by chemical vapor deposition, and the secondary antibodies (Anti-rabbit IgG) can be covalently bonded on the substrate through these functional groups. The microbeads conjugated with the primary antibodies were injected into the microchannel and captured by the secondary antibodies on the substrate. Then the buffer was injected into the microchannel with gradually increased flow rate. When the shear force was large enough to break the bonds, the microbeads will be washed away. In addition, we quantified the numbers of proteins on one bead with the use of fluorescently labeled protein by fluorescence intensity measurement. With the above experiment and model calculations, the binding force between the primary antibody and the secondary antibody can be calculated.

3. Results and Conclusion
In the measurement results, the binding force between the antibodies was 118 pN. Though the result is greater than the binding force between human IgG and anti-human IgG measured from other literatures based on AFM measurement, it was still very close. The measured interaction force is attributed to the bond, van der Waals force and electrostatic force. If the van der Walls force and electrostatic force can be eliminated by calculation, the force only contributed by the bond can be investigated. This work provides a way to measure binding force of proteins in a closed microchannel system for characterizing precision biosensors.

Keywords: Binding force, biosensor, microfluidics
Industrial Engineering (1)/ Mechanical Engineering

Tuesday, May 10, 2016  13:30-15:00  Room 1007

Session Chair: Prof. Kang Won Lee

ICEAI-1043
Topological Analysis of Seoul Subway Network Using Multiple Network Spaces
Kang Won Lee  |  Seoul National University of Science and Technology
Min Jung Kim  |  Seoul National University of Science and Technology

ICEAI-1116
The Effect of Depression of Train Drivers on Accidents: Focused on Mediating Effect of Cognitive Failure and Mistake
Tack-Hyun Shin  |  Seoul National University of Science and Technology
Tohir Yuldoshev  |  Seoul National University of Science and Technology
Shakhriddin Rustamov  |  Seoul National University of Science and Technology

ICEAI-1051
The Land Suitability Evaluation for Samut Prakan Province in Thailand for Eco Industry Development by Applying the Geographic Information System
Suphattra Ketsarapong  |  Sripatum University
Prapapan Ketsarapong  |  Kasetsart University Sriracha Campus

ICEAI-1057
Optical-Flow-Based Template Matching for Surface Defect Detection
Du-Ming Tsai  |  Yuan-Ze University
I-Yung Chiang  |  Yuan-Ze University
Wei-Yao Chiu  |  Industrial Technology Research Institute
ICEAI-1058
Effects of the Tapered Wound-on-Tension on the Inner Stress Distributions of Wound Rolls
Tachung Yang︱Yuan Ze University
Chiu-Tang Lin︱Tungnan University
Tung-I Tasi︱Chan Li Machinery Co., Ltd.
Cheng-Han Chang︱Chan Li Machinery Co., Ltd.
Ting-Chao Chen︱Chan Li Machinery Co., Ltd.

ICEAI-1078
A Potential Big Data Analytics Approach: Performance Evaluation of Random Forests Classification
Han-Tang Nien︱National Taipei University of Technology
Shu-Kai S. Fan︱National Taipei University of Technology
Topological Analysis of Seoul Subway Network Using Multiple Network Spaces

Kang Won Lee\textsuperscript{a}, Min Jung Kim\textsuperscript{b}

\textsuperscript{a}Department of Industrial and Information Systems Engr.
Seoul National University of Science and Technology, Seoul, Korea
E-mail address: kwlee@snut.ac.kr

\textsuperscript{b}Department of Industrial and Information Systems Engr.
Seoul National University of Science and Technology, Seoul, Korea
E-mail address: minjung9196@nate.com

Abstract
Characterizing the structural properties of the network is of fundamental importance to understand
the complex dynamics of networks such as neural network, social network, computer network, etc.
And structural properties of the subway network are very relevant for an effective transportation
management in urban cities. Three kinds of topological spaces including L-space, P-space and
R-space were introduced and subway network of Seoul was constructed under each space. And
some topological measures of Seoul subway network were derived in each space, which can be
used to identify structural properties and characteristics of the network. By combining and
analyzing all the measures from three different spaces we could have more clear understanding
and direction of future plans of Seoul subway network.

Keywords: Network Topology, L-space, P-space, R-space, Subway Network

1. Introduction
The subway network of Seoul, which started with the opening of Seoul Subway Line No.1 in 1974,
has expanded into 9 lines for the past 40 years. With 7 additional suburban lines connecting new
cities metropolitan subway network of Seoul becomes one of the largest subway networks in the
world. Since the subway network became the first in transportation mode share in 1996, the
subway mode share has taken upturn and became 38.8\% in 2013.

Analyzing and identifying the structural characteristics of the network play an important role in
understanding the complex dynamics and efficiency of the network. For this reason, by many
countries, there have been researches and studies about the efficiency of one's subway network
and the direction of future plans through mathematical and topological analyses of its structures
and properties\cite{1,2,3,4,5}.

Most studies were simply done with graphs which define subway stations as nodes and relations
between those as links. So, analysis treating subway networks in diverse topological spaces has
been actually insufficient. This paper intends to introduce three different topological
spaces (L-space, P-space and R-space) and develop network for Seoul subway system in each
space. And some topological measures will be derived in each space, which will be used to
identify structural properties and characteristics of Seoul subway network. By combining and
analyzing all the measures from 3 different spaces we can have more clear understanding and the
direction of future plans of Seoul subway network. Our analysis is limited to only 9 subway lines
of Seoul.

Metropolitan subway network of Seoul consists of 9 lines of Seoul and 7 suburban lines
connecting cities newly developed. During last 40 years it went through a significant evolutionary
processes. The growth model of network can be classified as expansion mode and intensification mode[6]. In this study, we also investigate the evolution processes of metropolitan subway network of Seoul and try to answer which modes it has went through. For this analysis we include 7 suburban lines as well as 9 lines of Seoul.

Following the Introduction three topological spaces will be discussed in Chapter 2. In chapter 2 some network topological measures will be also reviewed and summarized, which can be used identify the structural properties abd characteristics of the subway network. In chapter 3 we will derive several topological measures for all three spaces and analyze the Seoul subway network. The growth mode of metropolitan subway network will be discussed in Chapter 4 and final conclusions and summary in Chapter 5.

2. Topological Spaces of Network and Topological Measures
A network graph is composed of nodes and links. Normally, nodes represent the agents of network and links represent the interactions between agents. The network analysis was started from Graph theory of mathematics in 1960. In the field of social science, it has been discussed actively in the name of theory of social network. Nodes and links symbolize subjects and mutual relationships, respectively. The fundamental reason of rapid development in these theories is the capability of processing massive data and forming huge networks or models due to the improvement in information technologies. These days, various complex networks with diverse elements and interactions are analyzed in the fields of energy, biological and chemical systems, transportation, and Internet.

2.1 Topological Space
Networks of Seoul Subway are developed by defining nodes and links according to three topological spaces(L, P and R).

In L-space, subway stations are defined as nodes and links are seen when there are two stations connected in succession. Normally, the network in L-space is seen in a subway map.

In P-space, stations are expressed as nodes, but unlike L-space, links exist when two nodes are on the same subway line and a direct route between them is available without any transfer. That is, if there is a link between two stations, it means one station can be reached from the other station without transfer.

Lastly, in R-space, nodes represent subway lines. Links exist when it is possible to transfer from a line to another line directly, which means that a link exists if there is a transfer station between two subway lines.

Following Figure 1 shows the three topological spaces defined above.
In Figure 1, (a) is a subway network of 5 lines with 9 stations. Figures and letters represent subway lines and stations, respectively. (b) shows the network in L-space which has been used traditionally, where node represents the station and link the connection between two stations. (d) shows the network in P-space, where a link exists between every two stations in the same subway line. (d) is a subway network in R-space. The two links between the node 2 and node 5 notify that there are two transfer stations between the two subway lines. This can be also expressed as a single link with some weighting.

2.2 Definition of Topological Measures

Although many measures and quantities for complex networks are proposed, three measures including the average shortest path length, clustering coefficient, and node degree distribution are the most widely used to understand the complex dynamics of network. These are defined as follows.

- Clustering coefficient(C): It is a measure of how close a node's neighbors are to form a clique. It is based on triplets of nodes, where a triplet consists of three nodes that are connected by either two (open triplet) or three(closed triplet) undirected ties. Clustering coefficient is the percentage of closed triplets among all connected node triplets in the entire network.

- Average shortest path length(L): It is the average of shortest lengths(number of hops) between all nodes of network. Let N represent the number of nodes and L_{i,j} represents the shortest length between node i and j. Then, average shortest path length L is defined as
3. Analysis of Seoul Subway network

3.1 Topological Measures of Seoul Subway Network

Topological measures of Seoul Subway Network are derived and summarized in spaces L, P and R, which are shown in Table 1. For input data we have used the database of [7,8,9]. Since databases are updated until September, 2013, we analyze Seoul subway network of September, 2013. Seoul subway network consists of 9 lines (M) and 380 stations (N) in total.

Table 1: Topological Measures in Three Spaces

<table>
<thead>
<tr>
<th></th>
<th>L-space</th>
<th>P-space</th>
<th>R-space</th>
</tr>
</thead>
<tbody>
<tr>
<td>K</td>
<td>2.3</td>
<td>69.0</td>
<td>6.67</td>
</tr>
<tr>
<td>$K_{max}$</td>
<td>8.0</td>
<td>191.0</td>
<td>8.0</td>
</tr>
<tr>
<td>C</td>
<td>0.024</td>
<td>0.94</td>
<td>0.95</td>
</tr>
<tr>
<td>W</td>
<td>2.04</td>
<td>2.03</td>
<td>1.95</td>
</tr>
<tr>
<td>$W_{max}$</td>
<td>4.0</td>
<td>2.0</td>
<td>1.0</td>
</tr>
<tr>
<td>$W_{max}$</td>
<td>2.0</td>
<td>4.0</td>
<td>6.0</td>
</tr>
<tr>
<td>L</td>
<td>19.50</td>
<td>1.89</td>
<td>1.17</td>
</tr>
</tbody>
</table>

3.2 Analysis

1) Node Degree

Node degree which is the most basic property of L-space network is 2 except some transfer stations. So, average node degree 2.3 in L-space is quite natural. It radically increases to 69.0 in P-space. This is because, when defining P-space, every station in the same subway line is linked each other. At Jongro 3-ga station where line No.1, No.3 and No.5 meet together, the maximum node degree even appears to be $K_{max} = 191$. The fact that the average node degree is big means that nodes are interlinked better in each topological space.
Figure 2 shows the subway networks in R-space. While Figure (a) is constructed with a single connection line regardless of the number of transfer stations, the number of links between two stations in (b) represents the number of transfer stations. The average node degree is 6.67, which says on the average each line has 6.67 transfer points with some other lines. If we consider maximum of node degree in R-space is 8 (Since there are 9 lines), we can say all the lines are well connected with each other.

The following Figure 3 shows the degree distributions for three topological spaces.

As can be seen in (a) of Figure 3, node with degree 2 is the most frequent in degree distribution of L-space, which means that most subway stations are directly connected with two other stations. The next most frequent is node with degree 4. The stations with degree 6 are Jongno 3-ga station,
Faloutsos et al. [10] examined the AS (Autonomous System) topology of the Internet and found that node degrees are well described by power-laws of the form $y = x^{-\alpha}$. This type of network is characterized by a highly heterogeneous degree distribution. There is a few, but significant number of nodes with a lot of connections. Many real world network such as the WWW, metabolic system, and the Internet AS system can be characterized by power-law distribution of node degree [11, 12]. However, it is observed that the degree distributions of Seoul subway network under L, P and R-spaces do not follow the power-law distribution at all.

2) Clustering Coefficient

The clustering coefficient in L-space gets a very low value of 0.024. Practically, the value is close to 0 since it is hard to find the stations where its neighbor stations are interlinked except transfer stations. Subway network does not need to be fault-tolerant. Nobody does not expect the subway network to provide direct connection between neighboring stations when one station breaks down. Subway network is just one part of metropolitan public transportation network. If one station breaks down, there is other means of connecting neighboring stations such as bus and taxi. If we consider whole public transportation network, it should be fault-tolerant and must have high value of clustering coefficient.

Meanwhile, the clustering coefficients appear to be extremely high in P-space and R-space, 0.94 and 0.95, respectively. In P-space, because all stations in the same subway line are connected with each other, chances are very high that the neighbor stations of a subway station are directly connected. In R-space, the clustering coefficient represents the degree of mutual connectivity between subway lines. In order to see the effect of each line to mutual connectivity, the clustering coefficient is calculated after removing a subway line. The results are shown in the Figure 4.

![Fig. 4: Clustering Coefficient after removing One Line](image)

From Figure 4 we can see that clustering coefficient decrease below 0.9 when line 2, line 5, or line 7 is eliminated from the network of R-space. This is because these subway lines have the greatest number of transfer stations. On the other hand, clustering coefficient becomes slightly higher when line 8 is removed. This is because it has only three transfer stations, Jamsil station(line 2), Ogeum station(line 3) and Cheonh station(line 5).

3) Average Shortest Path Length

L is 19.5 in L-space, which means on the average any two stations are 19.5 hops apart in the shortest path. Watts and Strogatz [13] showed that some biological and social networks were not completely regular coupled nor random. They introduced small world network model, which is highly clustered like regular lattice, yet has small average shortest path length like random
network. It is known the small world network characterizes many real world networks such as the Internet, the social network, the biochemical network, and etc[14]. If we consider that clustering coefficient of Seoul subway network is almost negligible and L is relatively high compared to the number of node 380, usually L grows proportionally to the logarithm of number of nodes N in small-world network, Seoul subway network is far from small-world network.

In P-space, links exist when nodes are on the same subway line. That is, path length 1 means that it is possible to reach the destination through a single subway line with no transfer and path length 2 means that a transfer is needed. As seen in the Table 1, the average number of transfer of Seoul Subway is 1.89. Links can be weighted with the actual number of users between stations. Let $Q_{ij}$ represents the number of passenger between stations i and j. Then link between node i and j can be weighted as

$$E_{ij} = \frac{Q_{ij}}{\sum_{i \neq j} Q_{ij}}$$

With the links weighted using the above equation L becomes 1.52, which is much lower than that with the unweighted links. It says Seoul subway network needs less transfer between stations with high utilization, but more transfer between stations with low utilization. In the subway network of R-space L is only 1.17, which means all the lines are almost directly connected.

4) Average Link Weight
Since each link represents back and forth track in L and P spaces, W is almost 2. In R-space link weight is 1.95, which means on the average there are two transfer stations between any two lines.

4. Growth Model
Growth model is an approach to analyze the evolution of network from topological view. The growth of nodes and links in a network can be divided into two types; expansion mode and intensification mode. Expansion mode is the case that the network range becomes large and wide as network grows while intensification mode gets dense. In intensification mode, the network which has been already enlarged grows in the direction of higher inner cohesion by increasing the connectivity of nodes. The difference between the two modes is average shortest path length, L. It tends to get longer in expansion mode and smaller in intensification mode. In expansion mode, L increases since new nodes are created and the network can reach further with the addition of new links between existing and new nodes. Intensification mode provides more efficient and shorter routes by introducing new nodes inside the network and L becomes smaller. Generally, expansion mode precedes intensification mode. It is usual to repeat the processes of expansion and intensification. Expansion occurs first and then intensification of inner cohesion follows.
In this section, growth process of metropolitan subway network of Seoul from 2008 to 2013 has been analyzed. It includes 9 lines of Seoul and 7 suburban lines. The network had already 371 nodes in 2008 and 122 nodes were newly added during the period of 2008 to 2013. To show the actual expansion and intensification we have used the physical distance (in km) for L in Figure 6. Since the value of $L$ increases during the period of 2008 to 2011, we can say the network is in expansion mode overall during this period. This can be explained by the fact that several new lines connecting suburban areas were constructed from 2008 to 2011. These include Cheona-Sinchang (Line 1 extension), Paldang-Guksu (Line Jungang), Sangbong-Chuncheon (Line Gyeongchun) and Gimpo International Airport-Seoul (Line Airport Railroad). So, during the period of 2008 to 2011, it is seen to be in expansion mode, being developed as a massive subway network interlinking Gyeonggi-do, Cheonan and Gangwon-do.

From 2011 to 2013 L remains almost same although number of node increases by 33. We can say the network has the both modes of expansion and intensification during this period. During the period of 2011 to 2013 we had several new lines including Bundang line, New Bundang line and line 7 extension, which made the network dense. And also some lines including Suin line and Kyungui line made the network wide and large.

5. Conclusion and Summary

Three kinds of topological spaces including L-space, P-space and R-space were introduced and subway network of Seoul was constructed under each space. We have obtained several measures such as node degree, clustering coefficient, average shortest path length and average link weight under each space. By analyzing them we can get characterizing structural properties and more clear understanding of Seoul subway network.

The growth of nodes and links in a network can be divided into two types; expansion mode and intensification mode. The evolutionary processes of metropolitan subway network of Seoul from 2008 to 2013 has been analyzed. We found that it shows the properties of expansion mode during the period of 2008 to 2011 and both expansion mode and intensification mode during the period of 2011 to 2013.

6. References


ICEAI-1116
The Effect of Depression of Train Drivers on Accidents: Focused on Mediating Effect of Cognitive Failure and Mistake

Tack-Hyun Shin\textsuperscript{a,}\*, Tohir Yuldoshev\textsuperscript{b}, Shakhriddin Rustamov\textsuperscript{c}
\textsuperscript{a} Industrial Engineering, Seoul National University of Science and Technology, South Korea
E-mail address: shin6468@seoultech.ac.kr
\textsuperscript{b} Graduate School of IT Policy, Seoul National University of Science and Technology, Uzbekistan
E-mail address: t.yuldoshev@mail.ru
\textsuperscript{c} Graduate School of IT Policy, Seoul National University of Science and Technology, Uzbekistan
E-mail address: shakhrustamov@gmail.com

Abstract
In Korean society, the theme of human error in railway has been emerging as a critical issue than ever. As far as human error studies are concerned, main trend has been inclined to be led by industrial engineering and systems science. Apart from those trends, this study empirically highlighted the relationship between depression, which has been a frequent research subject in the medical science and psychology, and accidents, with setting depression as an exogenous variable and cognitive failure and mistake as endogenous variables, respectively. Results of hypotheses test for the 204 respondents showed that driver's depression has a significant effect on accidents mediated by cognitive failure and mistake. This finding suggests the need for exploring the diverse latent factors causing human errors and for understanding the complex cognitive process as well as for establishing integrative countermeasures to mitigate human errors.

Keywords: Depression, Cognitive Failure, Mistake, Accidents, Mediating Effect

1. Introduction
The over 70\% causes of road traffic accidents have come out the human error and in case of railroad, 51.6\% (1,781 of total 3,449 cases) of the accidents are also human error in 2007~2011 years[1]. As human error of the critical reasons of the accidents results from human information process or the error of cognitive function like cognitive failure, most research of human error have tried to find out the classification of human error types or the development of analysis tools other than the forecast of factors caused human error so far[2][3]. But todays, based on the industrial engineering and the system approach, psychological and behavioral sciences approach are accumulated with social concern about human error[4][5]. This phenomenon can be right due to the possibility of plentiful explanation about the influence factors of human error.

Recently, as social interest has been increased more and more in successive suicide of train drivers from errors and accidents caused by the depression and the panic disorder, the diverse and scholarly research is progressed as the subject about human error in train field. Nevertheless, research about the relation between the endogenous variable and the any effect on accidents caused by train driver’s depression has not almost done. The study focused on an epidemiologic relation between the train drivers’ depression and the accidents from cognitive error and failure empirically with main concept of the depression as a measure of mental health in this situation.

2. Previous Research And Hypothesis
The depression as a measurement of mental health is a severe illness caused the pain, the productivity decline and even the death of a person [6]. According to estimate, it is reported that 16\% of American people have experienced the depression in their life. Although the a lot of
studies and various models about the depression causes by medical scientists and psychologists have accumulated, most of conclusions indicated that the causes of the depression result from the negative experience in a process of growth in early years and the overexposed stress and the social isolation as an adult. The fundamental reason using the depression as the main construct concept in this research in research is that the depression can affect negatively the safety and the accidents in the organization. According to ‘Wikipedia’, the depressed patients (melancholiac) trend to keep negative emotional experience such as worthlessness, guilty conscience, regret, helplessness and detestation etc. as well as appeal the symptoms like fatigue, headache and indigestion in physical. Besides, they feel like the decline of concentration and memory, sleeplessness (insomnia) and even suicide impulse [7]. It is reported that the above depression symptoms can results in the negative effects of safety behaviors and accidents ultimately [8]. The empirical studies on the depression have done as follows.

Simpson (2005) verified that there is the significant difference between high group and low group of the depressed patients, who studied weather various factors including the depression affect the cognitive failure and accidents through the experiment which have done with 30,000 residents of rich and poor area in America or not. That is, high depression group has higher frequency of cognitive failure and accidents than low group through chi-square test with individual variables and the logistic regression analysis showed the significant relationship between the depression and cognitive [9]. Also, Jonathan (2008) reported the similar relationship between various ordinary cognitive such as attention and memory failures and the depression through the test of attention lapses and memory failures with students taking psychology class in Waterloo University [10]. In addition, lots of research through clinical tests with the depressed patients in terms of the cognitive progress reported that the depression is major factor to form the abnormal attitude and cognitive distortion such as selective abstract, overgeneralization, personalization and interpretational biases [11]. The latest research, which performed the experiment with drivers in domestic train by psychiatrists, reported that the number of accidents and the number of fatalities of drivers experienced depression are significant higher 2.6 and 1.5 times than those of inexperienced drivers respectively and 88.6% of drivers with depression appeal the subjective decline of concentration [12]. The above research showed that the depression as exogenous variable must be closely related with cognitive failure and error as endogenous variable as well as they have a cause-and-effect relationship with the accidents. In other words, the depression directly affects cognitive failure, error and accidents in literature review. To study the above discussions, there are the assumptions as follows;

[Hypothesis 1] the train driver’s depression must affect the accidents.
[Hypothesis 2] the train driver’s depression must affect the cognitive failure and error.

Meanwhile, a large number of studies showed the fact that cognitive failure is an important factor of accidents occurrence. The cognitive failure can be determined as the situation of disagreement between intention and behavior by the functional failure of perception, remembrance and motor nerves [13]. Reason (1990) firstly classified the human error into slip as execution error, lapse as storage error, and mistake as planning error and then described that slip and lapse are occurred by not observing the procedures and rules [14]. He also divided the failure of planned actions into planning error (mistake) and action error (cognitive failure) [15]. The cognitive failure is not dangerous particularly for itself but is closely associated with safety error and accident [16], car accidents, hospitalization, injury by falling and job accidents [17] in many researches, which approached cognitive failure as total construct concept.

There are another researches verified that the stress as important construct concept is related with the cognitive failure and accidents. Firstly, Day(2012) showed the fact that the stress by excessive job demands arouse the cognitive failure which affects the accidents [18], and Lee (2006) verified
the effect on safety behavior and accidents from the interaction between the cognitive failure and the stress [19]. Also, cognitive failure can be precedence factor to forecast the safety or unsafety behaviors and accidents, because it is reported that people with high cognitive failure tendency can make mistakes and violation frequently and have a lot of accidents and injury experiences [8].

Since it is difficult practically when using the accidents and injury as criterion variable, instead of them, recent field researches verified the relationship very closely between safety behavior and accidents as measurement like observance habit, mistake and violation [8]. The recent researches about KTX drivers also showed that the experience with handling system mistake is significant associated with miss-near and human error accidents [20]. To study the above discussions, there are the assumptions as follows;

[Hypothesis 3] the train driver’s cognitive failure must affect the accidents.
[Hypothesis 4] the train driver’s mistake must affect the accidents.
[Hypothesis 5] the train driver’s cognitive failure must affect the mistake as safety behavior measurement.

The above hypothesizes is described as individually cause-and-effect relationship based on direct effect among main construct concepts so far. In case of integration Hypothesis 1 and 2 with Hypothesis 3, 4 and 5, cognitive failure and mistake as endogenous variables can realize the variables as intermediary role in relation between the depression and the accident. From this point of view, the depression can be approached as a point of view on the indirect effect about accidents by cognitive failure and mistake instead of the variable as direct effect about accidents. Therefore, an assumption is needed as follows

[Hypothesis 6] the train driver’s depression must affect the accidents through the medium of cognitive failure and mistakes.

3. Research Design
3.1 Model and Measurements
Figure 1 depicted the research model to make the overall relationships among them used in previous research. In other words, the research aims to show the cause-and-effect relationship among major concepts including the depression, cognitive failure, error and accidents.

![Diagram](image)

**Fig. 1: The Model of the Study**
In order to apply the characteristic of business through interview with rich driving experienced managers, the questionnaires about the depression, cognitive failure and mistake variables used in
Park (2011) [8] are modified and supplemented, and the accidents variables, used by change into dummy variables, can be classified into human error accident in official personnel records and miss-near in non-records.

3.2 Response characteristics
The questionnaires distributed to 204 of working drivers in Pusan and Daejeon of ‘A’ train organization are collected. All respondents are male, and age groups are 93 people over 50-year-old, 78 men between 40 and 49, 24 men between 30 and 39. Also, the levels of education are 93 men in high school diploma, 55 men in college graduate and 54 men in university graduate. Other respondents’ characteristics are in table 1.

<table>
<thead>
<tr>
<th>Table 1: Demography of the Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor</td>
</tr>
<tr>
<td>Age</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Education</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Position</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Years of Service</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Human-Error Accident Experience</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Miss-Near Experience</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

4. Results
4.1 Validity and Confirmatory Factor Analysis
With use the multi-item scales for the construct concepts included in this research, ‘Likert 5 scale’ is used to measure the level of agreements about the relevant item contents. The final survey without missing value of 204 questionnaires collected is 175, the confirmatory factor analysis with them is employed to verify the validity of performance items using AMOS 5.0.

Before confirmatory factor analysis, though exogenous variables and endogenous variables are possible to measure the a few questions, there are any impossible limits to judge the plural questions about whether the accidents or not. In this research, since the research used single index of accidents to measure near-miss and human error accidents, estimations of single index to analysis them are used and analyzed. Generally, Minimum number 0.7 was used because the estimation of single index is used 0.7 or 0.8. The general method to set up the single index is to fix the measure error as (1-a) with 1 factor loading [21][22]. The result of the estimation is clear and the limitation of measurement questions is overcome because factor loading is unbiased estimation.
The application of goodness-of-fit in confirmatory factor analysis is important. When it is applied rigorously, RMSEA (mean square error of approximation) must be less than 0.08, GFI (goodness-of-fit index), NFI (normed fit index) and GFI (comparative fit index) must be over 0.9, and AGFI (adjusted goodness-of-fit index) must be over 0.8. The research removed the items impeding the validity due to not meeting the relevant criteria. Table 2 shows the model goodness-of-fit index after removing the items that impeded the validity. The goodness-of-fit indexes are $\chi^2=55.613$ (df=36, p=0.019), $\chi^2$/df=1.545, RMSEA=0.056, GFI=0.946, AGFI=0.902, IFI=0.972, NFI=0.925, CFI=0.971, and except sensitive $\chi^2$ about sample size. The model is suitable because the standard loading value in the model is over 0.5 and the composite reliability of each measurement variable is over 0.7. To analyze valid judgment of the measurement models, the results compared AVE of research units with the value of correlation coefficient showed that the valid judgment exit because AVE between two factors can be bigger than the square value of coefficient of correlation (Table 3).

Table 2: Results of CFA

<table>
<thead>
<tr>
<th>Construct concept</th>
<th>Item measured</th>
<th>Standard Loading value</th>
<th>S.E</th>
<th>t value</th>
<th>Concept Reliability</th>
<th>Index of VE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>A14</td>
<td>.814</td>
<td></td>
<td></td>
<td>.889</td>
<td>.730</td>
</tr>
<tr>
<td></td>
<td>A16</td>
<td>.797</td>
<td>.088</td>
<td>10.524</td>
<td>.889</td>
<td>.730</td>
</tr>
<tr>
<td></td>
<td>A18</td>
<td>.763</td>
<td>.082</td>
<td>10.111</td>
<td>.889</td>
<td>.730</td>
</tr>
<tr>
<td>Cognitive Failure</td>
<td>B12</td>
<td>.764</td>
<td>.109</td>
<td>9.120</td>
<td>.854</td>
<td>.660</td>
</tr>
<tr>
<td></td>
<td>B11</td>
<td>.705</td>
<td></td>
<td></td>
<td>.854</td>
<td>.660</td>
</tr>
<tr>
<td></td>
<td>B14</td>
<td>.901</td>
<td>.119</td>
<td>9.655</td>
<td>.854</td>
<td>.660</td>
</tr>
<tr>
<td>Error</td>
<td>D18</td>
<td>.838</td>
<td></td>
<td></td>
<td>.800</td>
<td>.580</td>
</tr>
<tr>
<td></td>
<td>D21</td>
<td>.763</td>
<td>.095</td>
<td>8.706</td>
<td>.800</td>
<td>.580</td>
</tr>
<tr>
<td></td>
<td>D23</td>
<td>.560</td>
<td>.083</td>
<td>8.080</td>
<td>.800</td>
<td>.580</td>
</tr>
<tr>
<td>Miss Near</td>
<td>Yes or No</td>
<td>.855</td>
<td>-</td>
<td>-</td>
<td>.936</td>
<td>.940</td>
</tr>
<tr>
<td>Human Error</td>
<td>Yes or No</td>
<td>.785</td>
<td>-</td>
<td>-</td>
<td>.911</td>
<td>.910</td>
</tr>
</tbody>
</table>

$\chi^2=55.613$ (df=36, p=0.019), $\chi^2$/df=1.545, RMSEA=0.056, GFI=0.946, AGFI=0.902, IFI=0.972, NFI=0.925, CFI=0.971

Table 3: Correlation Coefficient and AVE

<table>
<thead>
<tr>
<th>Construct</th>
<th>Depression</th>
<th>Cognitive Failure</th>
<th>Mistake</th>
<th>Miss-Near</th>
<th>Human Error Accident</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression</td>
<td>.730</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive Failure</td>
<td>.566</td>
<td>.660</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mistake</td>
<td>.575</td>
<td>.360</td>
<td>.580</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miss-Near</td>
<td>-.112</td>
<td>-.057</td>
<td>.191</td>
<td>.940</td>
<td></td>
</tr>
<tr>
<td>Human Error Accident</td>
<td>.378</td>
<td>.339</td>
<td>.392</td>
<td>.318</td>
<td>.910</td>
</tr>
</tbody>
</table>

4.2 Structural Equation results and Hypothesis Test
The structural equation is used to analysis of actual proof in the research. After testing all structural models in the research, the results deducted, $\chi^2=63.769$ (df=37, p=0.004), $\chi^2$/df=1.723, RMSEA=0.064, GFI=0.939, AGFI=0.891, IFI=0.962, NFI=0.913, CFI=0.961. The model in the research can be appropriate because the model is proper level compared with the general assessment indexes of covariance structural analysis. The results of path analysis in the research show in Table 4, and results of path coefficient depict in Figure 2. The results of hypothesis test are follows as:

Table 4: Results of Structural Model Path Analysis

<table>
<thead>
<tr>
<th>Path</th>
<th>Path Coefficient</th>
<th>S.E</th>
<th>t-value</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depression -&gt; Cognition Failure</td>
<td>.608</td>
<td>.099</td>
<td>6.249</td>
<td>.000***</td>
</tr>
<tr>
<td>Depression -&gt; Mistake</td>
<td>.547</td>
<td>.150</td>
<td>4.619</td>
<td>.000***</td>
</tr>
<tr>
<td>Depression -&gt; Human Error Accident</td>
<td>.119</td>
<td>.073</td>
<td>.790</td>
<td>.429</td>
</tr>
<tr>
<td>Depression -&gt; Miss-Near</td>
<td>-.280</td>
<td>.084</td>
<td>-1.744</td>
<td>.081</td>
</tr>
<tr>
<td>Cognition Failure -&gt; Mistake</td>
<td>.026</td>
<td>.137</td>
<td>.233</td>
<td>.816</td>
</tr>
<tr>
<td>Cognition Failure -&gt; Human Error Accident</td>
<td>.211</td>
<td>.049</td>
<td>2.040</td>
<td>.041*</td>
</tr>
<tr>
<td>Cognition Failure -&gt; Miss-Near</td>
<td>-.020</td>
<td>.068</td>
<td>-.155</td>
<td>.877</td>
</tr>
<tr>
<td>Mistake -&gt; Human Error Accident</td>
<td>.273</td>
<td>.048</td>
<td>2.177</td>
<td>.029*</td>
</tr>
<tr>
<td>Mistake -&gt; Miss-Near</td>
<td>.381</td>
<td>.055</td>
<td>2.838</td>
<td>.005**</td>
</tr>
</tbody>
</table>

***p<0.001, **p<0.01, *p<0.05

Fig. 2: The Path Model

Hypothesis 1, which the train driver’s depression must affect the accidents, didn’t show that the depression is not a significant direct effect on accidents as seen path model. Therefore, Hypothesis is not tested, while Hypothesis 2, which the train driver’s depression must affect the cognitive failure and error, is proved that path coefficients are significant cause-and-effect relationship as .678 and .547 respectively.

Meanwhile, when investigating the Hypothesis of relationship among the endogenous variables in case of Hypothesis 3, which is the relation between cognitive failure and accidents, cognitive
failure affects human error accidents but don’t relate miss-near. Therefore, Hypothesis 3 is proved partially. Hypothesis 4, which is relation between mistake and accident, is proved that mistake affects both human error accidents and miss-near. Hypothesis 5, which the cognitive failure as measurement of cognitive must affect the mistake as safety behavior measurement, is proved that there are no relation between them.

Lastly, Hypothesis 6, which the depression must affect the accidents through the medium of cognitive failure and mistakes, is proved that the depression don’t affect accidents directly but give an indirect effect through the medium of cognitive failure and mistakes as seen path model.

4.3 Analysis of Results
So far the research model and hypothesizes were proposed based on the review of the previous researches and hypothesizes tests were tried based on statistics results. Some implications showed as follows.

Firstly, this research approached as the extent of the depression as construct concept which psychology and researchers in the medical field handled as subject widely while existing researches deal with the drivers as main subjects studied mostly the stress and tiredness in case of train field. The result was verified that the train drivers’ depression is a very critical variable affecting accidents significantly in terms of cognitive fail and mistakes. In human errors’ point of view, as this research expanded a little more as microscopic viewpoint which the factors including cognitive failure and mistake affect the accidents as the fact found in the previous researches, the fact, which the searching approaches about various factors except stress and tiredness as the causes of accidents are need, is very important results in this research.

Secondly, the necessity of the concern and the support to manage the train drivers as safety workers with high mental loading is demanded through the organizational method about relief plan and the diagnosis of causal factor of the depression. That reason was that the drivers with high depression have much experience of accident, as reported in previous researches. With it, the understanding about intermediary function and working mechanism of cognitive failure and mistake is also needed in relation between the depression and the accidents because further understanding about exogenous and parameter variables can be essential knowledge to prevent and decrease the human error of train drivers.

Thirdly, in spite of the results of previous researches finding the cause-and-effect relationship between the cognitive failures and mistakes, this research cannot find the cause-and-effect relationship yet, which meet the results of Reason (1988)’ research that approach planning failure (mistake) and action failure (cognitive failure) as independent concepts respectively.

Lastly, when following the above Reason’ opinion, action failure (cognitive failure) have a significant effect on human error accident but don’t associate with miss-near clearly. It can be very important result to raise the cause analysis of cognitive failure and the need of diagnose, because it is meaning that human error accident can be happened in case of error in action step. On the other hand, mistake as error in planning step has a significant effect on human error accident and miss-near respectively. That is, it can be explained that though mistake can lead to human error accident, it is more relieved than cognitive failure as error in action step and then can finish miss-near only.

5. Conclusion
The tests are performed to analysis objectively the relationship of the depression and accidents in condition of the depression as exogenous variable and cognitive failure and error as endogenous variable in the research. The results of analysis from hypothesis test comes out the fact that the
depression is not the direct cause of accidents itself but the cognitive failure and error carried by the cognitive processes must affect the accidents. Reason asserted the error is classified into error (cognitive error) at acting level and error (mistake) as planning level. Two factors of cognitive failure and error is independent concept. The cognitive failure as error in acting level is high possible to have the human error accidents. The consequence like the above raise the necessity of basic understanding and diagnosis about an operating mechanism of cognitive error which is the cognitive failure and mistake as well as the diversified approach which the train drivers' human error can be the causal factor. With them, the continuous OJT (on the job training) of view of the depression, the cognitive failure and mistake is necessary and find ways to decrease and prevent human error by organizational level.

There can be obvious limit to apply the results of research to the generalization due to perform the test about the drivers in single organization only. Therefore, the extended research which include the research model with behavioral science concept and the research applied to qualitative methods such as experiments and depths interview to overcome the limits of quantitative methods like survey are necessary. Nevertheless, the research can be significance to deal with the relation of dynamics between the depression as a main construct, not including previous research with human error of train drivers, and the accidents involving recognition variables.

6. Reference


The purpose of this study is to present the Geographic Information System (GIS) that supports land suitability evaluation for the development of target land in Bang Pu Sub-District Municipality in Samut Prakan Province in Thailand in order to promote the concept of the eco-industrial town. GIS was applied as the research methodology. SIEVE analysis was employed to evaluate suitable land. There are four factors involved in evaluating the land in this study. The first factor is the industrial density factor. The second factor is the industrial cluster factor. The third factor is the accessibility to green and recreation areas factor. The last factor is the risk to the urban ecology and environment factor. Each factor has three score levels in descending order: 3, 2, and 1. It was found that suitable target land could be found in five locations. There were 408 industrial factories on the target land (68.92% of 592 Group 3 factories). The findings are important information for the Samut Prakan Provincial Office to select suitable land, to make strategic and master plans, and to manage resources in order to maximize efficiency and develop the province into a model eco-industrial town in accordance with the province’s vision.

Keywords: Eco-industrial town, Land Suitability, Geographic Information System, Thailand

1. Introduction

In the past, business conduct in most of the factories focused on managing and improving business processes in order to react to global trade rules and regulations, but ignored the other important conditions that would enhance business sustainability (Panyathanakun et al., 2013). For example, the impacts of the pollution released into the environment that affected the quality of life of the people living in the area were largely ignored (Audra J. Potts Carr, 1998). Factories are still not aware of zero waste production when raw materials are converted into goods (Liarska-Bizujojc et al., 2009). Therefore, there are many problems such as the lack of natural resources (water, energy, fuel, etc.), the reduction of forest, which destroys the ecology and biology, and global climate change, which impacts the whole world (Lowe and Evans, 1995; Liarska-Bizujojc et al., 2009; Chertow, 2007; Department of Industrial Works, 2012). Many researches around the world such as Lowe (1997), Chiu and Yong (2004), Roberts (2004), Chertow (2007), Park et al. (2008), Zhang et al. (2010), Marjan et al. (2011), Boons et al.(2011), Jung et al.(2013), Ketsarapong (2015) have introduced concepts of industrial ecology for sustainable development. The area development into an eco-industrial town is one of the solutions that will lead to sustainable growth of business, industry, environment and society (Ruckelshaus, 1989; Industrial Estate Authority of Thailand (IEAT), 2009; Xiangsheng, 2013). An eco-industrial town is development that focuses on economic ideas that seek to enhance profit, and ecological ideas that focus on balancing industry, community and environment. An eco industry is a group of businesses that manage resources effectively together, which leads to a balance in the economic, environmental and social...
aspects of the community (Ketsarapong, 2015). It focuses on a development strategy that co-exists with the environment, and this will lead to sustainable development (Ruckelshaus, 1989; Xiangsheng, 2013). The development of an eco-industrial town initially starts with the development of the ‘green factory’ to reduce and prevent external impacts. (Department of Industrial Works, 2012; Ketsarapong, 2015) For example, each factory is located in the same general location and improves the production line and develops the products to reduce the pollution that impacts the environment, as set by legal and environmental standards that have to be followed by applying clean production, green productivity, and eco-efficiency. When a factory becomes a green factory and continues to develop to win the support from industrial groups, it is possible to become an eco-industrial park or EIP (Xiangsheng 1995, Liu et al., 2014). For example, a green factory located in the same industrial group attempts to create a network to exchange production waste; uses an environmental management system, such as a wastewater treatment system, and has a friendly environmental production chain management system, the area can then be regarded as an eco-industrial town. This area will include and connect the industrial area and a group of factories, local stakeholders and surrounding communities and develop other things along with the industry. It can then be “a nice place to live with industry” (Ketsarapong, 2015). As a result, the development to an eco-industrial town is very necessary to build the integration at the factory group level to create a network of eco industries that has land suitability and no ecological disasters. The area that is ready with the basic infrastructure and traffic network is a city that supports the people living in the community. For all those reasons, development into an eco-industrial town requires the analysis the land suitability to assure that the area is suitable to be developed into an eco-industrial town. (Bunruamkaew and Murayama, 2011)

This research article is purposed to present Land Suitability Evaluation for the development into an eco-industrial town in the target area in the municipal of Bang Pu located in Samut Prakan province, Thailand using the Geographic Information System; GIS, which is a spatial data management system. It is useful for the Land Suitability Evaluation, which is a tool used extensively by the SIEVE Analysis technique. The factor data are converted into a geographic map and then all of the maps are overlaid according to Boolean algebra. The areas with higher scores will be overlaid on a geographic map. The result of the analysis is shown on a geographic map. This research article is divided into 5 parts: the introduction, the study Area, the methodology, the results of the research and the conclusion.

2. **Study Area**

The study area was determined by Samut Prakan Industry Office and other related offices of the province that work on the development of Samut Prakan as an eco-industrial town by selecting a study area in the municipality of Bang Pu, Samut Prakan province as shown in Figure 1.

![Fig. 1: A geographic map of the study area](image-url)
This area is quite important for the economics of this province. The area covers around 63.50 square kilometers. Its shape is rectangular and is along the east coast. Sukhumvit Road and irrigation canal are in the middle of the land starting from 29.250 kilometers on Sukhumvit Road to 51.150 kilometers. This area covers four Tambons including Thai Ban, Thai Ban Mai, Bang Pu and Bang Pu Mai. The population is 118,670 with 49,167 houses and 592 type 3 industrial factories. This area has factories and communities close to each other, which causes environmental problems quite often. The land development is pretty effective because it conforms to the 4 year development plan of Samut Prakan, (2015-2018) and the development plan of the municipality of Bang Pu (2014-2016). It also connects with the strategic planning of the development group of the provinces in central Thailand (Chachoengsao, Prachinburi, Nakhonnayok, Srakaew and Samut Prakan province). Therefore, this is an important reason why the municipal of Bang Pu was selected to be the study area for the eco-industrial town.

3. **Methodology**

To define the purposes, this research article was conducted with the research framework shown in Figure 2. There are four steps as follows:

3.1 **Step 1 Collect the data.**

This step starts with a field survey of the study area, the municipality of Bang Pu. The location is saved as the Global Positioning System (GPS) result for the factories in the study area. The primary data are collected by interviewing several stakeholders such as governors, factories and communities. Furthermore, secondary data are also collected, such as building use, which are then divided into industrial buildings, residential buildings, recreational buildings (with data from the Department of Public Works and Town & Country Planning) and other information needed for GIS, such as information categorized by type of industry from the International Standard Industrial Classification of All Economic Activities or ISIC. In 1986, there were factories that
received complaints about environmental problems which led to the Public Health Act in 1992 and the Hazardous Act in 1992. Information was also provided from Google Maps. All of the information mentioned above are analyzed to identify the factors, criteria and score and then land suitability is evaluated by GIS in steps 2 and 3, respectively.

3.2 Step 2 Identify factors and criteria or score.
This step is divided into two sub-steps: the first sub-step is to identify the factors which indicate the suitability of the area for development into an eco-industrial town. The factors are considered based on the data from step 1. A field survey of the physical, economic and social aspects is also conducted. Primary data are collected from interviews, and the secondary data are collected from several stakeholders. Related research articles are also reviewed. There were four main factors identified from the data: the industrial density factor, the industrial cluster factor, the accessibility to green and recreation area factor and the risk to urban ecology and environment factor. The second sub-step determines the criteria or score for each factor. The concept of factors and criteria or score identification are as follows:

3.2.1 Industrial density factor
Industrial factory integration will lead to convenient and energy safe ways of network building, or information exchange (Lowe and Evans, 1995). Moreover, this will lead to the procedure of technology exchange or resource sharing, such as a wastewater treatment system, and a trash management system, which will affect the success of the development of an eco-industrial town in the future. Therefore, an area that has industrial factory integration will be an area that is suitable for the development of an eco-industrial town. In this research article, the industrial density factor is identified based on building use, and the industry type is based on the classification by the Department of Public Works and Town & Country Planning. The score is determined by using the distance from factory to factory. The concept of traveling that saves energy the most is walking. According to the standards of the town planning of the Department of Public Works and Town & Country Planning, the average walking distance of Thai people is 500-800 meters subject to the environment of the area. In this research article, there is a radius connection and score, which is divided into 3 levels: 3 (0-500 meters), 2 (501-1,000 meters) and 1 (over 1,001 meters) as shown in Figure 3.

![Fig 3: The concept to determine the industrial density factor and score](image)

3.2.2 Industrial Cluster Factor
An industrial cluster is a group of businesses and related stakeholders that conduct their business in the nearby area (geographical proximity). They help, connect and support each other (commonality and complementary) in various ways such as services, commerce associations, seminar or development research to upgrade the capability of the competition by increasing productivity and creating innovations together. As a result, a group of the same type of industrial businesses will support the businesses and move the target area forward as an eco-industrial town. In this research article, the industrial group factor allocation is based on the information categorized by the type of the industry by the International Standard Industrial Classification of All Economic Activities or ISIC, which divides the industries into 9 clusters including the food
industry, the textile Industry, the wood Industry, the paper industry, the chemical product industry, the non-metallic mineral industry, the basic non-metallic mineral industry, the machine metallic industry and other production industries. The score is determined by using the distance from factory to factory the same type. The industries of the same type that are in walking distance will be more suitable for industrial cluster development and the average walking distance of Thai people is around 500-800 meters, subject to the environment of the area. In this research article, the radius connection and score are divided into 3 levels: 3 (0-500 meters), 2 (501-1,000 meters) and 1 (over 1,001 meters) as shown in Figure 4.

3.2.3 Accessibility to Green and Recreation Area Factor
A green or park zone can be developed to be a green buffer zone which can be used as the lung of industrial factories. It will help absorb pollution and dust that remains in the industrial zone. For the public, the benefits of a green zone can be as a recreation area of the community, and an indicator of the quality of life of those who live in the city (MOHURD, 2000; Liu et al., 2014). So if there is any area located in the service of the green or park zone, which means it tends to be developed as Green Buffer Zone and promote it to be an Eco-industrial town. In this research article, the factor of green and recreation area is based on the information about building use, the recreation type as classified by the Department of Public Works and Town & Country Planning, along with the field survey of the study area. The score is determined by using the distance to green and recreation areas in the city. The concept of traveling that saves energy the most is walking. According to the standards of the town planning of the Department of Public Works and Town & Country Planning, the average walking distance of Thai people is 500-800 m. subject to the environment of the area. In this research article, the Radius Connection and score is divided into 3 levels: 3 (0-500 meters), 2 (501-1,000 meters) and 1 (over 1,001 meters) as shown in Figure 5.

3.2.4 Risk to Urban Ecology and Environment Factor
Factories affect the surrounding area and ecology. They should be observed carefully. Therefore, if anyone located within the boundary line is affected by the factories and complains, that means there is a risk to the urban ecology and environment factor in that area. There should be a solution
to reduce the effects of factories on people living in the area. In this research article, the factors of the risk to the urban ecology and environment are based on the distance of the factories that receive complaints about the environment from the community. The score level is considered by the buffer zone which is divided into 3 levels; 3 (0-50 meter), 2 (51-150 meter) and 1 (151-500 meter) as shown in Figure 6. This refers to the report of the problems about the distance between the industry and the community in the Map Ta Phut Estate, Rayong province since this is a similar type of industry to the study area.

![Fig. 6: The concept to determine the risk to the urban ecology and environment factor and score](image)

After determining the factor and the score for the land suitability evaluation, there was a meeting with the working group for provincial development into an eco-industrial town. They finally identified 4 main factors: the industrial density factor, the industrial cluster factor (which was divided into 9 minor factors for each type of industry), the accessibility to green and recreation area factor and the risk to the urban ecology and environment factor. In total there are 12 factors in this research article. The factors and score are shown in Table 1.

<table>
<thead>
<tr>
<th>Factor</th>
<th>No. of Sub-Factor</th>
<th>unit</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>the industrial density factor</td>
<td>1</td>
<td>meter</td>
<td>0-500</td>
</tr>
<tr>
<td>the industrial cluster factor</td>
<td>9</td>
<td>meter</td>
<td>501-1,000</td>
</tr>
<tr>
<td>the accessibility to green and recreation area factor</td>
<td>1</td>
<td>meter</td>
<td>0-500</td>
</tr>
<tr>
<td>the risk to the urban ecology and environment factor</td>
<td>1</td>
<td>meter</td>
<td>151-150</td>
</tr>
</tbody>
</table>

3.3 Step 3 Land suitability evaluation

ArcView GIS 3.3 was used to create a map of land suitability by preparing a database and inserting the data using GIS for the land suitability analysis of each factor using SIEVE Analysis. This could be done by presenting the factor data on a map, such as creating a map of the industrial density factor which shows the density in 3 shades of color. The darkest color means the distance between each factory is 0-500 meters. The moderate color means the distance between each factory is 501-1,000 meters and the lightest color means the distance between each factory is over 1,000 meters. The resultant map including all 12 factors is shown in Figure 7.
After that, the maps are overlaid, which is called (Overlay Analysis) based on Boolean algebra (NC Division of Coastal Management and NC Center for Geographic Information and Analysis, 2005). GIS is used in this technique for analysis, and the concept is shown in Figure 8.

![Overlay Analysis Diagram](image)

**Fig. 7: A map of the analysis of land suitability for each factor**

4. **Results**

The analysis of 12 factors shows that each one has a chance to get a score (3, 2 or 1) so this means the maximum score is 36. After dividing the area into 4 class intervals by referring to Land Suitability Analysis User Guide of the NC Division of Coastal Management and the NC Center for Geographic Information and Analysis (2005), the research separates the scores into equal

<table>
<thead>
<tr>
<th>Input Theme A</th>
<th>Input Theme B</th>
<th>Output Theme C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,3</td>
<td>1,0</td>
<td>7</td>
</tr>
<tr>
<td>1,2</td>
<td>2,6</td>
<td>5</td>
</tr>
<tr>
<td>3,4</td>
<td>3,1</td>
<td>6</td>
</tr>
<tr>
<td>4,5</td>
<td>5,2</td>
<td>1</td>
</tr>
</tbody>
</table>

![Overlay SIEVE Analysis Table](image)

**Fig. 8: Overlay SIEVE Analysis using addition**

Next, the Total Suitability Score of all factors is determined. “S” is the Total Suitability Score, “N” is the number of factors and “R” is the weight of the suitability score of each factor from 1 to n as in equation (1).

\[ S = \sum_{i=1}^{n} R_i \]  

(1)

The area is then divided, this research article divided the area into 4 levels (or 4 intervals): The most suitable, good suitability, moderate suitability and the least suitable area.

3.4 **Step 4: the offer of land suitability with committees**

This step shows the results for land suitability for development into an eco-industrial town for the working group and committees. The results will be presented in the next section.
intervals, which is 9, as shown in Table 2.

Table 2: The interpretation of the score

<table>
<thead>
<tr>
<th>Score</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00-9.00</td>
<td>The least suitable area</td>
</tr>
<tr>
<td>9.01-18.00</td>
<td>A moderately suitable area</td>
</tr>
<tr>
<td>18.01-27.00</td>
<td>A good suitable area</td>
</tr>
<tr>
<td>27.01-36.00</td>
<td>The most suitable area</td>
</tr>
</tbody>
</table>

The results of the spatial analysis using GIS to determine land suitability for the development of Samut Prakan into an eco-industrial town are divided into the most, a good, a moderate and the least suitable areas. This analysis defines 5 areas as shown in Figure 9 and includes areas A1, A2, A3, A4 and A5.

Fig. 9: The results of land suitability in Samut Prakan province for development into an eco-industrial town

There are 408 out of 592 factories in the target area, which is equal to 68.92%. Furthermore, the analysis shows that there are 154 factories, which is equal to 26.01%, in area A3 covering the most suitable area with a size of 2.37 square kilometers as shown in Table 3.

Table 3: The details of the suitable area

<table>
<thead>
<tr>
<th>No.</th>
<th>Area</th>
<th>Tambon</th>
<th>Suitable Area (square kilometers)</th>
<th>Factory</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>most</td>
<td>good</td>
</tr>
<tr>
<td>1</td>
<td>A1</td>
<td>Thai Ban Mai</td>
<td>1.75</td>
<td>0.31</td>
</tr>
<tr>
<td>2</td>
<td>A2</td>
<td>Thai Ban</td>
<td>1.95</td>
<td>1.55</td>
</tr>
<tr>
<td>3</td>
<td>A3</td>
<td>Thai Ban</td>
<td>2.37</td>
<td>0.70</td>
</tr>
<tr>
<td>4</td>
<td>A4</td>
<td>Thai Ban &amp;</td>
<td>1.98</td>
<td>0.51</td>
</tr>
<tr>
<td>5</td>
<td>A5</td>
<td>Bang Pu Mai</td>
<td>1.19</td>
<td>0.32</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>9.24</td>
<td>3.39</td>
</tr>
</tbody>
</table>

| Percentage| 61.26| 22.46| 9.80| 6.48| 100 |

5. Conclusion
This research article presents the land suitability evaluation for the development of a target area in the municipality of Bang Pu, which is located in Samut Prakan, Thailand into an eco-industrial town. There are 4 main factors used for the analysis including the industrial density factor, the industrial cluster factor, the accessibility to green and recreation area factor and the risk to the urban ecology and environment factor. There are 3 score levels for each factor in descending order;
3, 2 and 1. The results of GIS show that there are 5 target areas (A1-A5) and there are 408 industrial factories, which is equal to 68.92%, of 592 Type 3 industrial factories. The area that is voted to be developed into an eco-industrial town is area A3 which covers Tambon Thai Ban with an area of 2.37 square kilometers. There are 154 industrial factories, which is equal to 26.01%. The result is important information for the Provincial Governor's Office to consider with regard to land suitability, strategic planning, master plan planning and effective resource allocation to develop the province into an eco-industrial town, which is in line with the vision of the province; moreover, this can be a prototype for other areas.

6. Acknowledgements
The researcher would like to thank the Provincial Governor's Office, Samut Prakan Provincial Industry Office, the Federation of Samut Prakan, the Chamber of Commerce of Samut Prakan, Sripatum University, Kasetsart University Sriracha campus and every stakeholder for the advice, data support and resources that helped the researcher achieve this research as purposed.

7. References


ICEAI-1057
Optical-Flow-Based Template Matching for Surface Defect Detection

Du-Ming Tsai\textsuperscript{a}, I-Yung Chiang\textsuperscript{b}, Wei-Yao Chiu\textsuperscript{c}
\textsuperscript{a} Department of Industrial Engineering & Management, Yuan-Ze University, Taiwan
E-mail address: iedmtsai@saturn.yzu.edu.tw
\textsuperscript{b} Department of Industrial Engineering & Management, Yuan-Ze University, Taiwan
E-mail address: s975423@mail.yzu.edu.tw
\textsuperscript{c} Industrial Technology Research Institute, Taiwan
E-mail address: willchiu@itri.org.tw

1. Background/ Objectives and Goals
The referential approach has been used widely for defect detection in complicated, patterned surface images. The currently available template matching methods such as golden template matching and normalized cross correlation are sensitive to displacement due to shifting and distortion of the object surface under test. False detection could severely occur around the edges of the patterned surface. In order to tackle the problem of conventional template matching techniques, we have proposed an optical-flow-based template matching for defect detection in this study.

2. Methods
Optical flow is conventionally a representation of local image motion by evaluating local derivatives in two consecutive images in the sequence. In defect detection, the magnitude of the optical flow of every pixel will be approximately zero if the two compared images resemble each other. Conversely, the pixel values of a defect in the inspection image are different from those in the template and, thus, the corresponding optical flow magnitudes will be distinctly large. The similarity measure based on the mean optical flow magnitude for each pixel defined in a small neighborhood window can accommodate displacement and product variations. The flow feature derived from the optical flow field is tolerated to misalignment and random product variation. The integral image technique is applied to replace the sum operations in optical flow computation, and speeds up the intensive computation. We have also analyzed the pitfall of the Lucas-Kanade optical flow for defect detection applications and proposed a swapping process by interchanging two compared images for optical flow computation.

3. Expected Results/ Conclusion/ Contribution
In this section, we present the experimental results of LED wafer dies in detail, and demonstrate the effectiveness of the proposed optical-flow defect detection method for textured surfaces of textile fabrics and non-textured surfaces of LCD color filters. LED wafers are low-end products in semiconductor manufacturing, the sizes and shapes could be slightly varied from die to die, and the dies are not well positioned in the wafer. In order to inspect individual dies in the wafer, the dies in the wafer image must be partitioned into small subimages, each containing exactly one LED die. In our implementation, all algorithms are coded in the C++ language and executed on a personal computer with an Intel Pentium Core2 Duo 3.00GHz processor. The processing time for an LED die image of size $115 \times 105$ pixels is only 0.012 seconds with the help of integral images, while it needs 0.053 seconds without using integral images. The experiment on light emitting
diode (LED) wafer die inspection has shown that the proposed method can achieve a 100% recognition rate based on a test set of 357 die images. Additional experiments on textured surfaces such as textile fabrics and non-textured surfaces such as color filters used in LCD panels have also shown that the proposed method outperforms the conventional template matching methods.

Keywords: Defect detection; Surface inspection; Template matching; Optical flow; Integral images; LED wafer inspection
ICEAI-1058
Effects of the Tapered Wound-on-Tension on the Inner Stress Distributions of Wound Rolls

Tachung Yang
Department of Mechanical Engineering, Yuan Ze University, Taiwan
Corresponding Author: mety@saturn.yzu.edu.tw

Chiu-Tang Lin
Department of Industrial Management, Tungnan University, Taiwan

Tung-I Tasi, Cheng-Han Chang, and Ting-Chao Chen
Chan Li Machinery Co., Ltd., Taiwan

Abstract
Effects of the tapered profiles of Wound-On-Tension (WOT) on the inner stress distributions (circumferential and radial) of the wound rolls were investigated by using in-house codes, based on Hankiel's numerical model. The results show that tapered WOT profiles can reduce the zone width of negative circumferential stress, compared with constant WOT profiles. Less final WOT in tapered tension profile is favorable. Nevertheless, the initial WOT affects the tightness between the core and the innermost layer and should be selected carefully.


Main Description
Roll winding has been used popularly in the continuous processing and converting of thin flexible webs, such as paper, fabric, plastic film, thin metal sheet, etc. Due to the effects of web material, core rigidity, and winding tension, winding defects, such as bursts, crushed core, wrinkling, loose core, starring, dishing, etc., may occur. The wound rolls also require enough strength to prevent deformation and damage during the storage and transportation periods. The inner stress distributions (circumferential and radial) of the wound rolls are complicated in that winding of each outer layer will affect the stresses of every inner layer already wound and these effects accumulate up to the add-on of the final layer, Fig. 1. The in-roll stress distributions and the winding tension control always attract wide attention to improve the quality of wound rolls. The Wound-On-Tension (WOT) is defined as the winding tension in the outer layer of web as the web being wound into a roll in the winding process. It is generally recognized that the tapered profile of WOT helps produce rolls of better quality. The tension taper ratio, which is the WOT of the outermost layer of the full roll to the WOT of first inner layer, should be between 0 and 50%, and 25% is commonly used.
The in-roll stress distributions (circumferential and radial) of the full roll have been analyzed for various taper ratios of WOT by using in-house codes, based on Hankiel’s numerical model. The results show all layers of web are under compression radially, Fig. 2, however, the layer pressure near the core can be tremendously high, which may cause crushed core. When the WOT decreases in tapered profile as the roll grows gradually, it seems that the WOT of the outer layers not much influence the stress distributions of the inner layers of the full roll, Fig. 3. Compared with constant WOT profiles in Fig. 4, tapered WOT profiles can reduce the zone width of negative circumferential stress (i.e., compressive hoop stress), which causes web looseness and wrinkling. Steeper taper profile of WOT produces less zone width of compressive circumferential stress, Fig. 5. Less WOT causes less maximum compressive stress. Therefore, under the same initial WOT for the innermost web layer, tapered tension profile with less WOT for outermost web layer would make less maximal compressive circumferential stress and less zone width of compressive circumferential stress. In short, less final WOT in taper tension profile is favorable. Nevertheless, the initial WOT affects the tightness between the core and the first layer. Larger or smaller initial WOT for the innermost web layer have their pros and cons, and must be selected carefully with the core properties, considering the effects of loose core and crushed core.
A Potential Big Data Analytics Approach: Performance Evaluation of Random Forests Classification

Han-Tang Nien and Shu-Kai S. Fan
Department of Industrial Engineering and Management,
National Taipei University of Technology, Taiwan, Republic of China
E-mail zcooltony@gmail.com

Abstract

The emergence of big data, social media, mobile, clouds computing and data analytics are fundamentally changing how we live, work and interact. Meanwhile, Big Data Analytics is becoming the world’s new natural resource, transforming industries and professions. In order to analyze the large volume of data, the big data analytics approach, Random Forests (RF), was examined the classification performance in advance. In this study, we applied the random forests, a machine learning method, to automatically separate the class from other classes. We evaluated the random forests classifier through a confusion matrix with four measures, the accuracy, precision, recall and F scores, for classification tasks on several benchmark datasets. The computational results demonstrated that the classification performances of the random forests classifier were satisfactorily good in all the tested datasets. Hence, the random forests showed some promise in big data analytics.

Keywords: Random Forests, Classification, Machine Learning, Performance Evaluation

1. Introduction

Random forest is a notion of the general random decision tree proposed by Breiman (2001), a class of learning algorithms for classification and regression tasks. As ensemble methods, they grow many trees as base learners and aggregate them to classify (Scornet, 2015). The random forests algorithms relies on a training dataset to learn the feature characteristics that may be used to separate one class from the others and applies the learned characteristics to make classifications for the test dataset. The random forests algorithm offers substantial improvements in classification accuracy and robustness to noise over common classification methods and becomes a popular choice for data classification (Cutler et al., 2007). The main purpose of this paper is to examine the classification accuracy of the random forests algorithm in terms of several benchmark datasets appearing in the literature.

2. Random Forests algorithm and Performance Measures

2.1 Random Forests algorithm

Random forest is an ensemble of classifiers that constructs multiple decision trees. A combination of tree predictors is created such that each tree depends on the values of a random vector or features independently sampled and assumed with the same distribution for all trees in the forests (Breiman, 2001). For each tree, the feature selection is randomly conducted, so the split node is also different from tree to tree, depending on what features have been picked. The basic steps of the random forests algorithm are summarized below:

1. Let the number of training cases be \( N \), and the number of variables in the classifier be \( M \).
2. Decide the number \( m \) of input variables to be used to determine the decision at a node of the tree; \( m \) should be much less than \( M \). In general, the number \( m \) is chosen to be the square root of \( M \) by default.
3. Choose a training set for this tree by choosing \( k \) times with replacement from all \( N \) available training cases.
4. For each node of the tree, randomly choose $m$ variables on which to make the decision at that node. Calculate the best split based on these $m$ variables in the training set.

5. Each tree is fully grown and not pruned.

At each node of the individual decision tree, the best split is chosen based on a random variable. Here, the “Gini Index” is used to calculate the gini value to determine the best split point. The random forests algorithm uses the gini index taken from the classification and regression tree (CART) learning system to construct decision trees. The gini impurity represents a measure of how often a randomly chosen element from the set would be incorrectly labeled if it were randomly labeled according to the distribution of labels in the subset. If a dataset $T$ contains elements from $N$ classes, the gini index is defined as (Harris, 2015):

$$Gini(T) = 1 - \sum_{j=1}^{N} (p_j^2)$$  \hspace{1cm} (1)

where $p_j$ is the relative frequency of class $j$ in $T$

If a data set $T$ is split into two subsets $T_1$ and $T_2$ with sizes $N_1$ and $N_2$, respectively, then the gini index of the split data is defined by

$$Gini_{sp}(T) = \frac{N_1}{N} gini(T_1) + \frac{N_2}{N} gini(T_2)$$  \hspace{1cm} (2)

The procedure flow chart of random forests algorithm as follow:
2.2 Performance Measures
The accuracy of a random forests classifier is evaluated through a confusion matrix as follows (Sokolova, 2009):

Table 1 Confusion matrix for binary classification.

<table>
<thead>
<tr>
<th>Actual</th>
<th>Predicted (classified)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive</td>
<td>TP</td>
<td>FN</td>
</tr>
<tr>
<td>Positive</td>
<td>True Positive (TP)</td>
<td></td>
<td>False Negative (FN)</td>
</tr>
<tr>
<td>Negative</td>
<td>False Positive (FP)</td>
<td></td>
<td>True Negative (TN)</td>
</tr>
</tbody>
</table>

**TP** is the number of correct predictions that an instance is positive.

**FP** is the number of incorrect predictions that an instance is positive.

**FN** is the number of incorrect predictions that an instance is negative.

**TN** is the number of correct predictions that an instance is negative.

The following table presents the most often used measures for binary classification based on the value of the confusion matrix.
Table 2 Measures for binary classification using the notation of confusion matrix

<table>
<thead>
<tr>
<th>Measure</th>
<th>Formula</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy</td>
<td>$\frac{T_p + T_n}{T_p + F_p + F_n + T_n}$</td>
<td>Proportion of the total number of predictions that were correct.</td>
</tr>
<tr>
<td>Precision</td>
<td>$\frac{T_p}{T_p + F_p}$</td>
<td>Proportion of the predicted positive cases that were correct.</td>
</tr>
<tr>
<td>Recall</td>
<td>$\frac{T_p}{T_p + F_n}$</td>
<td>Proportion of positive cases that were correctly identified.</td>
</tr>
<tr>
<td>F-score</td>
<td>$\frac{2 \cdot \text{Precision} \cdot \text{Recall}}{\text{Precision} + \text{Recall}}$</td>
<td>Relations between data’s positive labels and those given by a classifier.</td>
</tr>
</tbody>
</table>

3. Computational Results

3.1 Data Description and Parameter Setting

We chose two binary-class datasets and two multi-class datasets from the UCI repository. Table 3 gives a brief dataset summary. For each dataset, the number of features considered at each internal node is $m$, chosen as suggested by Breiman to be $m = \text{int}(\log_2 M + 1)$. A random 20% of the data is earmarked for training, and the remaining data for testing. To examine the classification performance of the random forests algorithm in every dataset, the number of trees ($n\_estimators$) in the forests is a crucial parameter for classification performance. The first is $n\_estimators = 50$; the second is $n\_estimators = 100$.

Table 3 Data set summary

<table>
<thead>
<tr>
<th>Data set</th>
<th>Train size</th>
<th>Test size</th>
<th>inputs</th>
<th>classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>70</td>
<td>275</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Diabetes</td>
<td>154</td>
<td>614</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>Waveform</td>
<td>1000</td>
<td>4000</td>
<td>21</td>
<td>3</td>
</tr>
<tr>
<td>Letters</td>
<td>4000</td>
<td>16000</td>
<td>16</td>
<td>24</td>
</tr>
</tbody>
</table>

3.2 Computational Results

The four metrics of $T_p, F_p, F_n, T_n$ have been developed from the confusion matrix to evaluate performance of classification (Sokolova, 2009). Four measures are defined in Table 2. The performances of these four measures (Accuracy, Precision, Recall and F-scores) were compared under two different numbers of trees in the forests. The experiments results are shown in Tables 4-9.

For the binary-class datasets, the dataset of Liver has 6 features, 345 records, and 2 classes with frequencies of about 42% and 58%. The other one (Diabetes) contains 8 features, 768 records and 2 classes with frequencies of about 35% and 65%. In Tables 4 and 5, we compared the performance measures with $n\_estimators = 50$ and $n\_estimators = 100$ on binary datasets. According to the experiments results, the performance measures with more trees are somewhat better than less trees.
In what follows, we would like to evaluate the performance measures on multi-class datasets with more records and features. Table 4 presents the performance measures on the dataset of Waveform. This dataset contains 21 features, 5000 records and 3 classes.

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Accuracy</th>
<th>Precision</th>
<th>Recall</th>
<th>F-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>0.730909</td>
<td>0.638298</td>
<td>0.79646</td>
<td>0.708661</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.809446</td>
<td>0.816555</td>
<td>0.9125</td>
<td>0.861865</td>
</tr>
</tbody>
</table>

Table 5 shows the performance measures of the dataset of Letters, which has 16 features, 20000 records and 24 classes. For the multi-class cases of the Waveform and Letters datasets, the classification results of the dataset of Letters are shown in Table 9.

<table>
<thead>
<tr>
<th>Datasets</th>
<th>Accuracy</th>
<th>Precision</th>
<th>Recall</th>
<th>F-1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>0.770909</td>
<td>0.760417</td>
<td>0.646018</td>
<td>0.698565</td>
</tr>
<tr>
<td>Diabetes</td>
<td>0.833876</td>
<td>0.865196</td>
<td>0.8825</td>
<td>0.873762</td>
</tr>
</tbody>
</table>

Table 9 The performance measures on Letters with n_estimators = 100

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Classes</th>
<th>Precision</th>
<th>Recall</th>
<th>F-1</th>
<th>F-0.5</th>
<th>F-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.99813</td>
<td>Class_0</td>
<td>0.977707</td>
<td>0.976153</td>
<td>0.976929</td>
<td>0.977396</td>
<td>0.976463</td>
</tr>
<tr>
<td>0.912245</td>
<td>Class_1</td>
<td>0.923445</td>
<td>0.955446</td>
<td>0.939173</td>
<td>0.929672</td>
<td>0.948869</td>
</tr>
<tr>
<td>0.97491</td>
<td>Class_2</td>
<td>0.97491</td>
<td>0.956063</td>
<td>0.965395</td>
<td>0.971082</td>
<td>0.959774</td>
</tr>
<tr>
<td>0.891813</td>
<td>Class_3</td>
<td>0.891813</td>
<td>0.954617</td>
<td>0.922147</td>
<td>0.903704</td>
<td>0.941358</td>
</tr>
<tr>
<td>0.93801</td>
<td>Class_4</td>
<td>0.93801</td>
<td>0.931929</td>
<td>0.934959</td>
<td>0.936787</td>
<td>0.933139</td>
</tr>
<tr>
<td>0.95098</td>
<td>Class_5</td>
<td>0.95098</td>
<td>0.925278</td>
<td>0.937953</td>
<td>0.945726</td>
<td>0.930307</td>
</tr>
<tr>
<td>0.952459</td>
<td>Class_6</td>
<td>0.952459</td>
<td>0.937097</td>
<td>0.944715</td>
<td>0.949346</td>
<td>0.940129</td>
</tr>
<tr>
<td>0.950661</td>
<td>Class_7</td>
<td>0.950661</td>
<td>0.92618</td>
<td>0.938261</td>
<td>0.945662</td>
<td>0.930975</td>
</tr>
<tr>
<td>0.979964</td>
<td>Class_8</td>
<td>0.979964</td>
<td>0.908784</td>
<td>0.943032</td>
<td>0.964849</td>
<td>0.92218</td>
</tr>
<tr>
<td>0.950172</td>
<td>Class_9</td>
<td>0.950172</td>
<td>0.960069</td>
<td>0.955095</td>
<td>0.952135</td>
<td>0.958073</td>
</tr>
<tr>
<td>0.960671</td>
<td>Class_10</td>
<td>0.960671</td>
<td>0.924875</td>
<td>0.915702</td>
<td>0.910286</td>
<td>0.921184</td>
</tr>
<tr>
<td>0.985075</td>
<td>Class_11</td>
<td>0.985075</td>
<td>0.962723</td>
<td>0.97377</td>
<td>0.980522</td>
<td>0.967112</td>
</tr>
<tr>
<td>0.945736</td>
<td>Class_12</td>
<td>0.945736</td>
<td>0.974441</td>
<td>0.959874</td>
<td>0.951341</td>
<td>0.968561</td>
</tr>
</tbody>
</table>

and 9 showed the classification results of the dataset of Letters, which has 16 features, 20000 records and 24 classes. For the multi-class cases of the Waveform and Letters datasets, the
random forests algorithm produced much better classification performances of the four measures than the binary-class cases of the Liver and Diabetes datasets.

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Class</th>
<th>Precision</th>
<th>Recall</th>
<th>F-1</th>
<th>F-0.5</th>
<th>F-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.87125</td>
<td>Class_0</td>
<td>0.868241</td>
<td>0.849478</td>
<td>0.858757</td>
<td>0.864422</td>
<td>0.853166</td>
</tr>
<tr>
<td></td>
<td>Class_1</td>
<td>0.869565</td>
<td>0.885886</td>
<td>0.87765</td>
<td>0.872781</td>
<td>0.882573</td>
</tr>
<tr>
<td></td>
<td>Class_2</td>
<td>0.87594</td>
<td>0.878582</td>
<td>0.877259</td>
<td>0.876467</td>
<td>0.878052</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Accuracy</th>
<th>Class</th>
<th>Precision</th>
<th>Recall</th>
<th>F-1</th>
<th>F-0.5</th>
<th>F-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.8775</td>
<td>Class_0</td>
<td>0.8912</td>
<td>0.830104</td>
<td>0.859568</td>
<td>0.878272</td>
<td>0.841644</td>
</tr>
<tr>
<td></td>
<td>Class_1</td>
<td>0.867911</td>
<td>0.907658</td>
<td>0.887339</td>
<td>0.875579</td>
<td>0.89942</td>
</tr>
<tr>
<td></td>
<td>Class_2</td>
<td>0.874724</td>
<td>0.895173</td>
<td>0.88483</td>
<td>0.878739</td>
<td>0.891007</td>
</tr>
<tr>
<td>Table 8 The performance measures on Letters with $n_{estimators} = 50$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
<td>-----------------</td>
</tr>
<tr>
<td><strong>Accuracy</strong></td>
<td><strong>Classes</strong></td>
<td><strong>Precision</strong></td>
<td><strong>Recall</strong></td>
<td><strong>F-1</strong></td>
<td><strong>F-0.5</strong></td>
<td><strong>F-2</strong></td>
</tr>
<tr>
<td>Class_0</td>
<td>0.972973</td>
<td>0.972973</td>
<td>0.972973</td>
<td>0.972973</td>
<td>0.972973</td>
<td>0.972973</td>
</tr>
<tr>
<td>Class_1</td>
<td>0.865325</td>
<td>0.922442</td>
<td>0.892971</td>
<td>0.876176</td>
<td>0.910423</td>
<td>0.910423</td>
</tr>
<tr>
<td>Class_2</td>
<td>0.958409</td>
<td>0.931459</td>
<td>0.944742</td>
<td>0.952895</td>
<td>0.936727</td>
<td>0.936727</td>
</tr>
<tr>
<td>Class_3</td>
<td>0.839385</td>
<td>0.940532</td>
<td>0.887085</td>
<td>0.857836</td>
<td>0.918399</td>
<td>0.918399</td>
</tr>
<tr>
<td>Class_4</td>
<td>0.912898</td>
<td>0.883306</td>
<td>0.897858</td>
<td>0.906822</td>
<td>0.88907</td>
<td>0.88907</td>
</tr>
<tr>
<td>Class_5</td>
<td>0.905941</td>
<td>0.872814</td>
<td>0.889069</td>
<td>0.899116</td>
<td>0.879244</td>
<td>0.879244</td>
</tr>
<tr>
<td>Class_6</td>
<td>0.920608</td>
<td>0.879032</td>
<td>0.89934</td>
<td>0.911981</td>
<td>0.887044</td>
<td>0.887044</td>
</tr>
<tr>
<td>Class_7</td>
<td>0.910314</td>
<td>0.871245</td>
<td>0.890351</td>
<td>0.902222</td>
<td>0.878788</td>
<td>0.878788</td>
</tr>
<tr>
<td>Class_8</td>
<td>0.966851</td>
<td>0.886824</td>
<td>0.92511</td>
<td>0.949711</td>
<td>0.901752</td>
<td>0.901752</td>
</tr>
<tr>
<td>Class_9</td>
<td>0.920742</td>
<td>0.947917</td>
<td>0.934132</td>
<td>0.926052</td>
<td>0.942354</td>
<td>0.942354</td>
</tr>
<tr>
<td>Class_10</td>
<td>0.899174</td>
<td>0.90818</td>
<td>0.903654</td>
<td>0.900961</td>
<td>0.906365</td>
<td>0.906365</td>
</tr>
<tr>
<td>Class_11</td>
<td>0.978261</td>
<td>0.948136</td>
<td>0.962963</td>
<td>0.972084</td>
<td>0.954012</td>
<td>0.954012</td>
</tr>
<tr>
<td>Class_12</td>
<td>0.931142</td>
<td>0.950479</td>
<td>0.940711</td>
<td>0.934947</td>
<td>0.946548</td>
<td>0.946548</td>
</tr>
<tr>
<td>Class_13</td>
<td>0.924528</td>
<td>0.916002</td>
<td>0.920548</td>
<td>0.922932</td>
<td>0.918176</td>
<td>0.918176</td>
</tr>
<tr>
<td>Class_14</td>
<td>0.905158</td>
<td>0.900662</td>
<td>0.902905</td>
<td>0.904255</td>
<td>0.901558</td>
<td>0.901558</td>
</tr>
<tr>
<td>Class_15</td>
<td>0.907154</td>
<td>0.926905</td>
<td>0.916923</td>
<td>0.911036</td>
<td>0.922886</td>
<td>0.922886</td>
</tr>
<tr>
<td>Class_16</td>
<td>0.839031</td>
<td>0.94847</td>
<td>0.890401</td>
<td>0.858851</td>
<td>0.924357</td>
<td>0.924357</td>
</tr>
<tr>
<td>Class_17</td>
<td>0.92268</td>
<td>0.910169</td>
<td>0.916382</td>
<td>0.920151</td>
<td>0.912644</td>
<td>0.912644</td>
</tr>
<tr>
<td>Class_18</td>
<td>0.967427</td>
<td>0.928125</td>
<td>0.947368</td>
<td>0.959302</td>
<td>0.935728</td>
<td>0.935728</td>
</tr>
<tr>
<td>Class_19</td>
<td>0.9728</td>
<td>0.932515</td>
<td>0.952232</td>
<td>0.964467</td>
<td>0.940303</td>
<td>0.940303</td>
</tr>
<tr>
<td>Class_20</td>
<td>0.933549</td>
<td>0.947368</td>
<td>0.940408</td>
<td>0.936281</td>
<td>0.944572</td>
<td>0.944572</td>
</tr>
<tr>
<td>Class_21</td>
<td>0.927914</td>
<td>0.963376</td>
<td>0.945313</td>
<td>0.934796</td>
<td>0.956068</td>
<td>0.956068</td>
</tr>
<tr>
<td>Class_22</td>
<td>0.9374</td>
<td>0.940419</td>
<td>0.938907</td>
<td>0.938002</td>
<td>0.939813</td>
<td>0.939813</td>
</tr>
<tr>
<td>Class_23</td>
<td>0.950241</td>
<td>0.945687</td>
<td>0.947958</td>
<td>0.949326</td>
<td>0.946594</td>
<td>0.946594</td>
</tr>
</tbody>
</table>

| Table 9 The performance measures on Letters with $n_{estimators} = 100$ |
|-------------------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| **Accuracy**                 | **Classes**     | **Precision**   | **Recall**      | **F-1**         | **F-0.5**       | **F-2**         |
| Class_0                      | 0.977707        | 0.976153        | 0.976929        | 0.977396        | 0.976463        | 0.976463        |
| Class_1                      | 0.923445        | 0.955446        | 0.939173        | 0.929672        | 0.948869        | 0.948869        |
| Class_2                      | 0.97491         | 0.956063        | 0.965395        | 0.971082        | 0.959774        | 0.959774        |
| Class_3                      | 0.891813        | 0.954617        | 0.922147        | 0.903704        | 0.941358        | 0.941358        |
| Class_4                      | 0.93801         | 0.931929        | 0.934959        | 0.936787        | 0.933139        | 0.933139        |
| Class_5                      | 0.95098         | 0.925278        | 0.937953        | 0.945726        | 0.930307        | 0.930307        |
| Class_6                      | 0.952459        | 0.937097        | 0.944715        | 0.949346        | 0.940129        | 0.940129        |
| Class_7                      | 0.950661        | 0.92618         | 0.938261        | 0.945662        | 0.930975        | 0.930975        |
| Class_8                      | 0.979964        | 0.908784        | 0.943032        | 0.964849        | 0.92218         | 0.92218         |
| Class_9                      | 0.950172        | 0.960069        | 0.955095        | 0.952135        | 0.958073        | 0.958073        |
| Class_10                     | 0.90671         | 0.924875        | 0.915702        | 0.910286        | 0.921184        | 0.921184        |
| Class_11                     | 0.985075        | 0.962723        | 0.97377         | 0.980522        | 0.967112        | 0.967112        |
| Class_12                     | 0.945736        | 0.974441        | 0.959874        | 0.951341        | 0.968561        | 0.968561        |
4. Conclusion.

This study has evaluated the performances of the random forests algorithm in the classification task. According to the results from 錯誤! 找不到參照來源。 to 9, it was shown that the random forests algorithm with \( n\_estimators = 100 \) performed slightly better than that with \( n\_estimators = 50 \). On the whole, the random forests algorithm was showed to be a powerful classifier that was able to yield very high classification accuracy. On the large datasets, the random forests algorithm could be executed with high efficiency and also handle many input variables without variable deletion. Based on this preliminary evaluation, the random forests algorithm can become a potential big data analytics approach for a wide variety of research fields.

5. References


Civil Engineering (1)/ Environmental Sciences (1)

Tuesday, May 10, 2016  15:15-17:15  Room 1006

Session Chair: Prof. Yung-Chih Wang

ICEAI-1209
Investigation on Design Parameters of New Reinforced Concrete Structures
Li-Wen Ho | National Central University
Yung-Chih Wang | National Central University

ICEAI-1242
Centrifuge Modelling on Performance of Building Structures with Different Foundation Types in Liquefied Ground
Jin Hung Hwang | National Central University

ICEAI-1041
Effects of Paints for Building Envelopes on Indoor Thermal Insulation in Subtropics
Chih-Hong Huang | National Taipei University of Technology
Pei-Hsuan Kao | National Taipei University of Technology
Yu-Hsuan Chang | National Taipei University of Technology

ICCBES-1053
Development of Indoor Air Quality (IAQ) Benchmarking System in Hong Kong
Kwok-Wai Mui | The Hong Kong Polytechnic University
Ling-Tim Wong | The Hong Kong Polytechnic University
Tsz-Wun Tsang | The Hong Kong Polytechnic University

ICEAI-930
Evaluating the Efficiency of Basalt and Glass Fibres on Resisting the Alkaline, Acid, and Thermal Environments
Sami Elshafie | University of Bolton
Gareth Whittleston | University of Bolton
ICEAI-978
Simulation of Hysteresis Response of Prestressed Concrete Member
Suppachai Sinthaworn | Srinakharinwirot University
Susumu Kono | Tokyo Institute of Technology
Hidekazu Watanabe | Tokyo Institute of Technology
ICEAI-1209
Investigation on Design Parameters of New Reinforced Concrete Structures

Li-Wen Ho\textsuperscript{a} and Yung-Chih Wang\textsuperscript{b}
\textsuperscript{a}ME student and \textsuperscript{b}Professor, Department of Civil Engineering,
National Central University, Taiwan
E-mail address: wangyc@ncu.edu.tw

1. Objectives
The reinforced concrete with higher steel strength ($f_y=685\text{MPa}$) than traditional reinforcement ($f_y=420\text{MPa}$) is so called as New Reinforced Concrete (New RC). Nowadays, the New RC starts considering the construction materials of high-rise buildings in Taiwan. The objective of the research is to investigate the seismic design parameters of New RC structures for structural analysis. These parameters are the overstrength of SD685 reinforcing steels and effective initial stiffness of flexural members.

2. Literature Review
The design parameters of the flexural overstrength and the effectively initial stiffness for building structures are the important factors in the seismic design. The strength limitation of steel reinforcement specified in recent design codes (ACI 318, 2011) is only up to 420 MPa. Andronio and Park (1986) claimed that the overstrength for beam is primarily determined by characteristics of reinforcing steel. For instance, NSZ 3101 (2006) took 1.25 times the nominal strength for Grade 300E, 1.4 for Grade 500E, and ACI 318 (2011) determined 1.25 for steel strength below 420MPa. Brooke (2011) concluded that the overstrength factor could be 1.4 regardless of the type of reinforcements. Moreover, the effectively initial stiffness, $E,I_e$, affected the results of structural analysis in the service and ultimate stages. The seismic design provisions (ACI 318, 2011) for the conventional RC structures currently suggested the stiffness ranging from $0.6E,I_g$ to $0.35E,I_g$.

3. Brief Results
This report discussed the differences in structural strength and deformation between the steel reinforcement used for SD420 and SD685. Until now, 73 experimental data from many countries were collected to provide the research on the overstrength factor and the effectively initial stiffness.

The overstrength factor was obtained by the ratio of maximum measured moment at about the member story drift ratio of 4% to the nominal moment calculated from the specified yield strength of the steel reinforcement. The statistical results are depicted in Figure 1. The mean value of the overstrength for SD685 steel rebar is 1.15 and the variance is 0.024.

The effectively initial stiffness $E,I_e$ was estimated according to the 75% secant method, which uses a secant line from the origin point to 75% maximum load for expressing the member stiffness at a yield state (service limit state). It is shown in Fig. 2 that the effectively initial stiffness of New RC members is obviously smaller than the traditional RC members. Besides, all types of the RC sectional moment inertia $I_e$ varies clearly with the aspect ratio ($l/h$). This finding revealed that the member stiffness should consider basing on the structural aspect ratio, $l/h$, rather than on a constant value for all structural aspects as the suggestion of the recent design codes (ACI 318 and NZS 3101). Further investigation on the effective moment inertia for rational structural analysis is needed.

Keywords: New RC, SD685 steel reinforcement, overstrength factor, effectively initial stiffness, seismic design.
4. References


ACI Committee 318(2011). *Building code requirement for structural concrete & Commentary*. American Concrete Institute.

ICEAI-1242
Centrifuge Modelling on Performance of Building Structures with Different Foundation Types in Liquefied Ground

Jin-Hung Hwang
Professor, Department of Civil Engineering, National Central University, Taiwan
E-mail address: hwangjin@cc.ncu.edu.tw

1. Objectives
A series of centrifuge shaking table tests were performed to investigate the settlement and seismic behavior of building with different types of foundation in liquefiable ground. Testmodels are divided into two groups according to the height of structure but with the same weight. The settlements and tilts of those structures were measured during and after seismic loading. The test results can provide a preliminary guide to selecting foundation type for those building structures in foundation soil susceptible to liquefaction under seismic action.

2. Literature Review
The first field observation on the settlement behavior of building was made by Yoshimi (1977) after 1964 Niigata earthquake. Since that time, the effect of soil liquefaction on the deformation behavior of building structures has always been attracting much attention from those researchers devoting to soil liquefaction engineering. The experimental study on this topic is very difficult owing to its complicated soil-structure interaction until the equipment of shaking table on centrifuge was developed. Dashti et al. (2008) performed a series of study on seismic behavior of buildings in liquefiable ground and reported the settlement mechanism of building caused by soil liquefaction. However, the model structures were not real structures. They were only dead loads with different shallow foundation sizes.

3. Brief Results
This study built real model building structures of one, three and five stories with spread footing, mat foundation, basement foundation, and pile foundation, as shown in Figure 1. The LVDTs, pore pressure transducers, accelerometers, and earth pressure transducers were installed at different locations to monitor seismic responses of model ground and structures, as shown in Figure 2. The accumulated settlements of different buildings due to soil liquefaction after multi-seismic event are shown in Figure 3. The major results are summarized as: (1) soil liquefaction can effectively reduce the seismic vibration of superstructure, however, can induce significant settlement of building due to soil softening under self-weight of building ; (2) The more story, the more settlement for the buildings with the same foundation ; (3) The building with end bearing pile has nearly no settlement. The one with spread footing has the largest settlement. The settlement of mat foundation is the second large. The settlements of buildings with basement or friction pile foundation are in between the above foundations, but the settlement of basement is less than that of the friction pile.
Fig. 1: Model buildings with different foundations

Fig. 2: Layout of different transducers

Fig. 3: Accumulated settlements of one and five buildings with different foundation types

Keywords: soil liquefaction, building’s settlement, centrifuge, foundation type.

4. Reference
ICEAI-1041
Effects of Paints for Building Envelopes on Indoor Thermal Insulation in Subtropics

Huang Chih-Hong*, Kao Pei-Hsuana, Chang Yu-Hsuanb
a Department of Architecture, National Taipei University of Technology, Taiwan
E-mail address: huangch@ntut.edu.tw

b Department of Civil Engineer, National Taipei University of Technology, Taiwan
E-mail address: michaelcool97217247@gmail.com

Abstract
In subtropical environments, solar radiation is the main heat source for building envelopes. Unlike the traditional way of structural thermal insulation, painting materials for external walls of buildings are light and thin and perform considerably well in reflecting radiation. This study examines differences in thermal insulating effects between a new painting material and a traditional paint using bare concrete walls respectively coated with a cement paint and a new thermal insulating paint as specimens and observes the process in which the specimens coated with the paints absorb solar radiation, store and release heat in an indoor scenario. For this study, an experiment was conducted on the procedures for measuring albedo using a pyranometer and heat flow sensor patches in accordance with ASTM. To control the experimental variables, measurements were taken in an indoor experimental site to eliminate factors affecting the wind field. Using a fixed number of halogen lamps to simulate solar radiation, observations and actual measurements were made and taken in terms of surface temperature change and the effect of radiative heat transfer in the concrete specimens under the irradiation of the simulated summer sunlight. Throughout the experiment, solar radiation, temperature and humidity, upper and lower surface temperatures were also monitored using a pyranometer and the data were entered into the computer to create trend comparison charts. Based on the results in these charts and heat flux, assessments were made on how excellent the thermal insulating and heat preserving properties of both paints are and thermal conductivity coefficients were measures for the painting materials. Findings of this study show that the new thermal insulating paint is more effective in thermal insulation than the traditional white paint by blocking nearly 27 W/m² of heat from penetrating to indoors, which is better thermal insulation than mere 13W/m² by the latter. This clearly indicates that blocking heat from the invisible part of the sunlight is also crucial. The new paint is light, thin, cost effective and simple compared with the traditional method of structural thermal insulation and shows an immense potential as a thermal insulating paint that blocks overall heat transfer in green buildings.

Keywords: building envelope, indoor thermal environment, insulating paint, solar radiation

1. Background/ Objectives and Goals
The radiant energy delivered to the earth surface from the sun through radiation represents the direct or indirect source that provides most of the heat on the earth. Despite the increased use of low albedo materials as paving and building materials in cities, urban heat islands that nonetheless occur still cause persistent high temperatures in subtropical urban areas in summer. The consequent high temperature and hot weather leads to increased energy consumption by air conditioning equipment for indoor comfort and increased total energy consumption for reproduction.

Understanding the physical properties of building envelopes properly and being able to block thermal loads in these envelopes accurately are the key technologies for improved energy
efficiency in buildings. Thermal insulation against solar radiation in the tropics is slightly different from that for winter heating in the frigid zones because heat transfer from direct sunlight is directional. This means that excellent thermal insulation can be achieved as long as heat conduction is blocked.

This study therefore takes in account all factors related to the effects of paints for building envelopes on thermal balance, including radiation from the visible part of the sunlight, reflection of light from building structures and heat conduction inside building envelope, based on research on buildings and urban thermal environments.

Due to the diverse spectrums of solar radiation, it is not easy to thoroughly differentiate the heat transfer performance by individual spectrums at different frequencies. However, by obtaining differences in measured heat flux through the upper and lower surfaces of the specimens and levels of radiation reflected by them and comparing the data with those measured from bare concrete, it is possible to infer detailed physical properties of paint coatings for thermal insulation.

Excellent thermal resistance technologies for building envelopes can effectively improve thermal environments both inside and outside buildings and reduce air conditioning energy consumption in buildings. However, as concrete is the most commonly used material for building envelopes in Taiwan, this highly heat accumulating material leads to heat accumulation on wall surfaces exposed to solar radiation in the daytime and increased indoor temperatures caused by constant heat release to indoors as a result of heat transfer within building walls and convective heat exchange with indoor air in the nighttime (Ma & Bo, 2008). Building envelopes, being a key component of building appearances and images and the interface that connects the indoor and the outdoor, can make significant differences to temperatures generated under the influence of solar radiation that comfort levels in indoor thermal environments depend upon (Eduardo & Baruch, 2008; Maria, 2007).

The key to solving the issue of indoor thermal environments is to effectively prevent the heat from solar radiation and surroundings from entering building walls and increase the total heat transferred by convection on wall surfaces. Oliveti provided a detailed description of thermal radiation exchange on external walls and roof surfaces (Oliveti, 2003). As effective thermal insulation works for external walls are costly, the simplest and most cost effective way is none other than thermal insulation using paints.

![Diagram](image)

**Fig. 1** A relationship diagram depicting the state of heat transfer over external surfaces (Tsai, Huang & Lee, 2014)

Building envelopes receive most of the heat inside and outside them from external heat sources and the commonly adopted radiation absorption rate for their concrete surfaces is 0.65-0.70 (Yao & Yan, 2011). However, factors such as surface coarseness and internal temperature gradient of their material and intensity of solar radiation all can influence results. To obtain the amounts of solar radiation actually absorbed into building structures of the experimental specimens, it is necessary to convert absorption rates at different times of the day. As shown in the surface heat
balance equation, apart from temperature rises and fluctuations in heat transfer over external surfaces in building envelopes due to solar radiation, it is also necessary to consider total heat transferred by convection between air and external wall surfaces and the reflection and longwave emission rates of the material itself. The heat balance equation for building envelopes is represented by the following equation (1) and a relationship diagram depicting the state of heat transfer over external surfaces is shown in Fig. 1 (Tsai et al., 2014).

\[
Q_t = Q_b + Q_i + Q_c + Q_r
\]

\(Q_t\): Total solar radiation reaching the external wall surface, w/m²
\(Q_b\): Amount of reflection from the external wall surface, w/m²
\(Q_i\): Heat absorbed by the external surface wall, w/m²
\(Q_c\): Heat transferred by convection between the external wall surface and the surrounding air
\(Q_r\): Longwave radiation emitted between the external wall surface and surrounding objects

Heat transfer between external wall structures of buildings is a fairly complex physical phenomenon, which includes heat absorption, release and conduction by external wall structures. Not only the process involves the three basic forms of heat transfer, conduction, radiation and convection, but also the analysis of heat transfer can see different changes according to the time of the day because temperature, wind speed and amount of solar radiation in the external environment change over time (Liu & Ming, 2004). To measure heat fluctuations on external wall surfaces of buildings in both ventilated and non-ventilated environments, the experiment for this study is placed in an indoor setting, thereby simplifying all the control variables for the calculation of heat transfer on the external wall surfaces. With cumulative observed results of heat accumulation and conduction over time, it is possible to show on the time axis that this model is balanced because of cumulative heat absorptions and dissipations (Huang et al., 2015).

2. Methods

The radiant heat experiment for this study compared concrete specimens that were either bare or respectively coated with white, black and/or CP thermal insulating paints. The experiment measurement took place under halogen lamps that illuminated the specimens at close range for 6 successive hours to simulate the sunlight. Throughout the 6-hour period, temperatures in, heat flux through, amounts of radiation to and reflection from the upper and lower surfaces of the specimens were recorded constantly.

The experiment was conducted in accordance with the US reference specification, the ASTM-E1918-06 standard, which requires outdoor measurement on sunny days to take place between 9 am and 15 pm to ensure the angle of incidence of the sun at less 45 degrees.

As it was not possible for the pyranometer to detect reflected heat at the height of 50 cm due to the size of the specimens, the overall height was lowered. Therefore, the following measured amounts of reflection were those obtained at the designed height for the experiment. The overall configured height is shown in the schematic Fig. 2.

In addition, the heat flow measurement referred to the ASTM-C518 specification, which requires that the thickness of specimens must be less than 250 mm and the heat flow sensor must be placed between the heating source and the specimen. The heat flow meter for this study was therefore installed in accordance with the specification (see Fig. 3).
To eliminate the need of controlling the wind field factor from this study, the outdoor measurement operation was moved to an indoor setting. The heat source used included four 4 500 W halogen lamps. The instrument installation fully complied with the aforementioned ASTM-E1918-06 specification, including the pyranometer (for measuring radiant heat), the support and the instrument distance.

The heat source was changed to 4x500W halogen lamps that merely had a near infrared range of wavelengths, 375~1100 nm. The sunlight wavelengths were in the range of 300~2500 nm. The wavelength range detectable by the pyranometer was 305~2800 nm. Heat flow sensor patches were respectively attached to the upper and lower surfaces of the specimens in accordance with the ASTM-C518 specification.

The concrete specimens were 15 cm thick and surrounded by Styrofoam (5 cm thick) on the four sides to prevent heat loss from the sides. The lab was also equipped with a thermo-hygrometer to keep the lab at a fixed temperature. The start indoor temperature and humidity were 22 ℃ and 35%. Testing was carried out over the period between November 26 and 30, 2015. The total test time per specimen was 360 minutes. One piece of data was captured every 5 minutes (see Fig. 4).

To obtain data as comprehensive as possible, this experiment included the following five
specimens to be measured:

(1). A bare concrete specimen (CON) for measuring baseline data
(2). A concrete specimen coated with a white thermal insulating CP paint (CPW): the target paint of this study
(3). A concrete specimen coated with a white cement paint (DUW): as the reference for comparing thermal insulating performance
(4). A concrete specimen coated with a black thermal insulating CP paint (CPB): as the control thermal insulating paint sample
(5). A concrete specimen coated with a black cement paint (DUB): as the control thermal absorbing sample

Observations were made on the temperatures, heat flux and penetration through the upper heating surface and the lower penetrated surface of each specimen. The effect of latent heat was not considered in this experiment. As the indoor temperature was controlled at the normal state (22°C), the effect of heat transfer through convective air was also not considered.

3. Results/ Discussion

Starting with the bare concrete specimen, measurements were taken separately. Each specimen was exposed to the lamps for 6 consecutive hours for the investigation into the thermal insulating mechanism of each analyzed paint.

The measured data showed that upper and lower surface temperatures of the specimens gradually rose and became stabilized after 360 minutes of exposure (see Fig. and Table 1). The temperatures in the case of the white cement paint were markedly much lower, in agreement with the universally acknowledged reflection effect of light colors (see Table 2).
The white DU cement paint appears to fall far behind its CP counterpart, which contains metal atoms and is evidently more effective in thermal insulation (see Table 3), which is not limited to the reflection of radiant energy associated with visible lights reflected by the white color.

In the generally acknowledged spectrum of the sunlight, the distribution of heat transfer is about 46% at visible light frequencies, about 52% at infrared frequencies and about 2% at ultraviolet frequencies. Ranges of visible light and infrared spectrums have evidently become the key to thermal insulation for buildings.

The white color of both paints is evidently able to block radiation at visible light frequencies only. The white CP thermal insulating paint appears to be able to block radiation in heat transfer at infrared frequencies as well. Therefore, the white CP paint that is able to block radiation both at visible light and infrared frequencies appears to have the greatest thermal insulation efficiency.

When using concrete, a material known for storing a lot of heat, it is especially important to take precautions that prevent heat from flowing into envelop walls. Naturally, better thermal insulating results can be achieved if the heat storage performance of the material used for wall structures is changed.

The statistics of the different specimens show huge temperature differences. The black cement paint appears to be able to absorb heat from visible lights, resulting in the highest upper and lower surface temperatures in the DUB specimen, which are much higher than those in the CON specimen. The DUW specimen performs better than its CON counterpart. The white CP thermal insulating paint performs evidently best in thermal insulation, resulting in both the lowest upper and lower surface temperatures in the CPW specimen.

**Table 1: Temperatures in the CON specimen**

<table>
<thead>
<tr>
<th>°C</th>
<th>Start temperature</th>
<th>Endpoint temperature</th>
<th>Average temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper surface</td>
<td>22.25</td>
<td>53.49</td>
<td>45.81</td>
</tr>
<tr>
<td>Lower surface</td>
<td>22.31</td>
<td>43.11</td>
<td>34.56</td>
</tr>
<tr>
<td>Temperature difference</td>
<td>0.06</td>
<td>10.38</td>
<td>11.25</td>
</tr>
</tbody>
</table>

**Table 2: Temperatures in the DUW specimen**

<table>
<thead>
<tr>
<th>°C</th>
<th>Start temperature</th>
<th>Endpoint temperature</th>
<th>Difference from CON</th>
<th>Average temperature</th>
<th>Difference from CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper surface</td>
<td>21.8</td>
<td>48.65</td>
<td>-4.84</td>
<td>42.88</td>
<td>-2.93</td>
</tr>
<tr>
<td>Lower surface</td>
<td>22.04</td>
<td>39.85</td>
<td>-3.26</td>
<td>32.45</td>
<td>-2.11</td>
</tr>
<tr>
<td>Temperature difference</td>
<td>0.24</td>
<td>8.8</td>
<td>-</td>
<td>10.43</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 3: Temperatures in the CPW specimen.**

<table>
<thead>
<tr>
<th>°C</th>
<th>Start temperature</th>
<th>Endpoint temperature</th>
<th>Difference from CON</th>
<th>Average temperature</th>
<th>Difference from CON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper surface</td>
<td>19.27</td>
<td>42.39</td>
<td>-11.1</td>
<td>37.50</td>
<td>-8.31</td>
</tr>
<tr>
<td>Lower surface</td>
<td>18.24</td>
<td>34.14</td>
<td>-8.97</td>
<td>26.79</td>
<td>-7.77</td>
</tr>
<tr>
<td>Temperature difference</td>
<td>1.03</td>
<td>8.25</td>
<td>-</td>
<td>10.71</td>
<td>-</td>
</tr>
</tbody>
</table>
Notably, the black CP thermal insulating paint causes extremely high upper surface temperatures in the CPB specimen, indicating that the black color absorbs a lot of heat, and lower surface temperatures close to those in the CON specimen. Therefore, it can be inferred that the paint coating to the upper surface absorbs heat from visible lights while blocking that from infrared radiation so that it is possible for it to generate lower surface temperatures close to those in the CON specimen.

The heat transfer or storage performance of concrete is not within the scope of this discussion. Nevertheless, it is worth noting whether the cement or thermal insulating paints hinders the dissipation of heat stored in the concrete specimens although such hindrance to heat dissipation is not present in the CON specimen. This issue merits further investigation.

The best way to block thermal energy is to reflect solar radiation directly back to the sky. Fig. 7 shows huge albedo differences between various envelope materials and their order indicates a fully consistent positive correlation with the temperatures in the specimens (see Table 4). Unfortunately, the instruments used in this study are unable to differentiate the spectral distribution and energy ratios of reflected radiation. There is still no detail mechanism that can clearly describe the action of reflection.

In his measurement of distribution of reflected solar radiation, Aoki demonstrated the decisive effect of the materials for reflective surfaces. In his comparison of concrete tile, artificial turf and woodchips, concrete tile contributed to low altitude ambient temperatures that were 3-5°C higher (Aoki & Mizutani, 2015). This author has noticed the issue of longwave radiation in Aoki’s study, but his experiment was also unable to differentiate the reflection of light with different wavelengths.

It is only possible to surmise based on color differences and physical principles that a significant portion of high radiation reflection should be infrared reflection. The heat flow sensor patches reveal differences greater than temperature differences due to the way in which the heat penetrates.
After 6 hours of light exposure, the large amounts of heat absorbed by the black paints have already been able to penetrate to the lower surface, which means that the heat have already penetrated to the indoor space. The maximum heat flux indicated is about 94.2 W/m$^2$. The heat flux through the lower surface is 62.4 W/m$^2$ for the CON specimen and 35.21 W/m$^2$ for the CPW specimen.

This method of heat conduction is able to accurately show the influence quantities to indoor comfort and room cooling efficiency in subtropics. The results show that the new thermal insulating paint is more effective in thermal insulation than the traditional white paint by successfully blocking nearly 27 W/m$^2$ of heat from penetrating to indoors, which better thermal insulation than mere 13W/m$^2$ by the latter. The white CP thermal insulating paint can block 43% more of thermal penetration than the bare concrete and 27% than the white cement paint. The effect is extremely significant. In terms of the thermal resistance effect, the difference evidently lies in the capability of blocking infrared heat.

Bonifacius used aluminum foil as roof insulation in tropical Indonesia but revealed that the aluminum foil was unable to effectively block radiative heat transfer (Bonifacius, 2012). It is evident that blocking visible lights alone cannot effectively prevent solar radiation from penetrating roofs. It is therefore necessary to find a more efficient insulation solution against radiant heat. Roslan measured glazed roofing materials and revealed their excellent thermal insulating capability (Roslan et al., 2014). However, the detailed thermophysical properties of these materials are not yet clarified.

![Fig. 7. Reflection (albedo) by specimen](image)

Table 4: Reflection (albedo) by specimen

<table>
<thead>
<tr>
<th></th>
<th>Halogen lamps</th>
<th>CON</th>
<th>CPW</th>
<th>DUW</th>
<th>CPB</th>
<th>DUB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount of reflection</td>
<td>662</td>
<td>133.5</td>
<td>267</td>
<td>222.5</td>
<td>89</td>
<td>0 W/m$^2$</td>
</tr>
<tr>
<td>Albedo</td>
<td>-</td>
<td>20.17%</td>
<td>40.33%</td>
<td>33.61%</td>
<td>13.44%</td>
<td>0%</td>
</tr>
</tbody>
</table>
The difference that visible lights and infrared light make to thermal insulation performance has introduced another issue: can different weather conditions, such as different cloud covers, cause changes in the effectiveness of thermal insulation?

Given that summer temperatures remain high, the effect of the large amount of heat stored in the air on heat storage in envelopes should not be overlooked even if envelopes are not directly exposed to the sunlight. Blocking visible lights alone cannot effectively prevent solar radiation from penetrating roofs. It is therefore necessary to find a more efficient insulation solution against radiant heat.

This study has demonstrated the significant effect of the thermal insulating paint. It produces an effect similar to that of a 'mirror panel'. (Pasztory, 2013) It produced an effective thermal insulation of the air by multiple heat reflection of the radiation heat flux. Several thermal insulation methods with lightweight construction are receiving increasing attention and being increasingly developed.

Various thermal insulation methods for building envelopes have revealed the importance of thermal impact. In terms of the cost of structures for building envelopes, the thermal insulating paint evidently has a greater economic advantage, making it worth more R&D efforts from the professional community.

4. Conclusion/ Contribution

The testing on heat conduction by the thermal insulating paint based on the measurements in the experiment shows that it performs better in thermal insulation than the traditional white cement paint and is significantly effective in thermal resistance as the paint for building envelopes in subtropics. The thermal insulating paint especially has the enormous advantages of ease of construction and structural cost effectiveness over traditional thermal insulation methods for building walls.

The heat transfer experiment on the paint shows that blocking visible lights alone has limited effects. The particles in the paint seem to have the effect of blocking infrared heat, which has been
overlooked until now, but should represent enormous potential in thermal insulation. Therefore, a lot of effort should be invested in the R&D of the full spectrum thermal insulation technology.

References
ICCBES-1053
Development of Indoor Air Quality (IAQ) Benchmarking System in Hong Kong

K.W. Mui\textsuperscript{a}, L.T. Wong\textsuperscript{b}, T.W. Tsang\textsuperscript{c}
\textsuperscript{a} Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China
E-mail address: behorace@polyu.edu.hk

\textsuperscript{b} Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China
E-mail address: beltw@polyu.edu.hk

\textsuperscript{c} Department of Building Services Engineering, The Hong Kong Polytechnic University, Hong Kong, China
E-mail address: tsangtszwun@gmail.com

1. Background/ Objectives and Goals
Measuring all indoor air pollutants in workplaces might be the ideal path to identify the need for mitigation of IAQ problems; however, the manpower and resources involved might not be cost-effective for the desired solution. An “IAQ index”, the average fractional dose of representative indoor air monitoring parameters, has been used as a screening parameter for detecting the unsatisfactory IAQ. The assessed environment is also benchmarked by a five-star rating system of IAQ performance which is based on the IAQ index generated from 422 air-conditioned offices.

2. Methods
The proposed IAQ index is the average fractional dose of surrogate monitoring parameters include carbon dioxide (CO\textsubscript{2}), respirable suspended particulates (RSP) and total volatile organic compounds (TVOC). The exposure limits in “Good” class of the IAQ Certification Scheme by HKEPD are adopted as the denominator for computing the IAQ index, and the usefulness of performing the test can be assessed by the value of likelihood ratio, which indicates that the test result is associated with unsatisfactory IAQ.

The benchmark is generated from the profile of IAQ indices of 422 randomly chosen air-conditioned offices in Hong Kong. For simplicity and easy implementation, the benchmarking system is divided into five categories which are symbolized by the number of stars according to the criteria proposed by Blume (1998). The performance of the rating system is illustrated by comparing the pollutant levels in offices with 1-star and 5-star rating among 422 randomly selected offices. A total of 103 Grade A office data, which are expected to have better IAQ due to their well-maintained centralized air-conditioning system, are used to evaluate the ability of the system in distinguishing offices with different IAQ class with reference to the existing IAQ Certification Scheme.

3. Expected Results/ Conclusion/ Contribution
Together with previously reported samples, the screening levels of common IAQ parameters were evaluated. The result could provide an overall representation of IAQ situation in Hong Kong offices including the ranges, arithmetic means (AM), arithmetic standard deviations (ASD), geometric means (GM) and geometric standard deviations (GSD) of the measured parameters respectively. This study also presents the development of a user-friendly five-star IAQ benchmarking system to quantify the likelihood of unsatisfactory IAQ.

97
Evaluation of the benchmark shows that when 1-star and 5-star data rated by the benchmark are checked against the IAQ index according to the IAQ Certification Scheme, 97.6% of the 1-star offices are considered to have unsatisfactory IAQ. On the other hand, only 9.5% unsatisfactory rate is found in offices with 5-star benchmark. Among the 103 Grade A offices, 37 and 40 offices are rated as 5-star and 4-star, which when compare with other random office samples, a significantly higher frequency is observed. Since Grade A offices have better management of maintenance and cleaning of air-conditioning system, better IAQ are expected and the benchmarking system effectively rates them with higher ranking among all other office samples.

The proposed benchmark could generally give consistent results with both the full IAQ certification scheme and in grade A offices; this measure is representative in general IAQ in office and could be considered as a IAQ indicator. The system would be useful for policymakers and professionals to evaluate the relative IAQ performance of indoor environment, and allow early diagnosis of IAQ problems to satisfy existing Hong Kong IAQ standards. The 5-star benchmark also serves as a convenient tool for building management to showcase the building IAQ ranking among all offices in Hong Kong for providing better IAQ information to tenants and occupants.

4. Acknowledgement
This research project is funded by the Public Policy Research Funding Scheme from the Central Policy Unit of the HKSAR Government (Project No: 2014.A6.038.14E).

Keywords: Indoor Air Quality (IAQ), IAQ index, benchmarks, screening
ICEAI-930
Evaluating the Efficiency of Basalt and Glass Fibres on Resisting the Alkaline, Acid, and Thermal Environments

Sami Elshafie 1, Gareth Whittleston 2
1Department of Civil Engineering, University of Bolton, Greater Manchester, UK
   Email: sami.elshafie@hotmail.co.uk
2Department of Civil Engineering, University of Bolton, Greater Manchester, UK
   Email: g.whittleston@gmail.com

Abstract
Over the past few years, basalt fibre has been used extensively as a reinforcement material in the construction industry, and close attention has been paid to its qualities, especially its excellent chemical and thermal resistance. In view of the significance of basalt fibre as a strengthening material, and to evaluate the long-term durability of basalt fibre, four different experimental works were performed, namely: resistance to alkalinity and acid environment tests, thermal resistance tests on fibres, measuring weight change of fibres, and observing the microstructure and element change of fibres using the Scanning Electron Microscope (SEM) and Energy Dispersive X-ray (EDX). In the past, there have been few studies on the chemical and thermal resistance of basalt fibres, most researchers focused on the effect of the strongest alkaline and acid chemicals such as Hydrochloric acid (HCL), and Sodium hydroxide (NaOH) as well as water on basalt fibres, but paid little attention to the effect of different alkaline and acid chemicals containing different pH levels. This research aims to fill this gap in the literature by evaluating the efficiency of basalt fibres in resisting different strong and weak alkaline and acid chemicals containing different pH levels, and also evaluates the capability of basalt fibres to resist several thermal degrees. For comparison purposes, glass fibres were also tested. The results showed that basalt fibres were more capable of restoring their strength than glass fibres when immersed in different alkaline and acid environments, and were more capable of resisting high heat, in particular resisting temperatures of 300° and 500°. Whereas glass fibres were more capable of resisting the low heat, in particular resisting temperatures of 50° and 100° better than basalt fibres. In this context, the chemical and thermal resistance of basalt fibres becomes an important parameter as a strengthening material for the construction industry.

Keywords: Basalt Fibre, Glass Fibre, Chemical and Thermal Resistance.
Simultauin of Hysteresis Response of Prestressed Concrete Member

Suppachai Sinthaworn  
Department of Civil Engineering, Faculty of Engineering,  
Srinakharinwirot University, Thailand  
Email address: suppachai@g.swu.ac.th

Susumu Kono  
Materials and Structures Laboratory, Tokyo Institute of Technology, Japan  
Email address: kono@serc.titech.ac.jp

Hidekazu Watanabe  
Materials and Structures Laboratory, Tokyo Institute of Technology, Japan  
Email address: watanabe@serc.titech.ac.jp  
*The corresponding author: Suppachai Sinthaworn

Abstract
To study the behavior of prestressed concrete members under cyclic loading, a fiber model was used in order to simulate hysteresis response and backbone curves of prestressed concrete beams. Effects of confining and plastic hinge length consist in the model and cyclic rule of constitutive models of materials. The analytical study reveals that the developed fiber model, which used the proposed simple concrete model with steel model of Menegotto and Pinto, is capable to capture quite well lateral load - drift angle relationships of unbond post-tensioned beams. However, further study is needed to capture the residual drift angle.

Keyword: Prestressed Concrete, Hysteresis Response, Fiber Model, Capacity-Drift Relation.

1. Introduction
Prestressed concrete members have been used as precast segments, girders, and columns in the world. In order to understand the behavior of reinforce concrete structures during earthquake, the hysteretic behaviors of reinforce concrete structures must be made clear. An envelope and hysteretic of moment-curvature relationship could be obtained.

The computational analysis (i.e. moment-curvature relationship, shear-drift angle relationship) of reinforced concrete structures subjected to cyclic loadings requires realistic stress-strain material models to reproduce the behavior of the structure. Therefore, the cyclic constitutive models of materials have been continuously developed. In 2004, Chang et al. modified Kent and Park model to improve the effect of confinement in concrete as shown in Figure 1. In order to simulate the cyclic loading, the hysteresis unloading and reloading rules of concrete were also proposed by Kent and Park (1971) and Yassin (1994) as shown in Figure 2 and Figure 3. Sima et al. (2008) developed a cyclic constitutive model for concrete in both compression and tension side as shown in Figure 4. Particular emphasis was placed in to the description of the strength and stiffness degradation produced by the cyclic loading in tension and compression, the shape of unloading and reloading curves and the transition between opening and closing of cracks. However, the models have become increasingly complicated but the models do not necessarily simulate all members under different conditions.
Therefore, objective of this study is to develop a simple concrete model for using in fiber models to predict the hysteretic characteristics of members in cyclic loading as shear force - drift angle relationship (moment-curvature relationship).

2. Fiber model and concrete constitutive models

2.1 Fiber model

This paper presents a fiber model to simulate nonlinear inelastic behaviors of unbonded post-tensioned beams. The fiber model takes into account the non-linear cyclic behavior of each material, the geometrical dimensions of the beams and the mechanical properties of concrete, mild steel reinforcement and unbonded prestressing tendons. The constitutive law for steel employed Menegotto and Pinto model (Menegotto and Pinto, 1973). The concrete constitutive law is based on the proposed simple concrete model (Sinthaworn, 2015). The procedure is iterated until the equilibrium of axial force is reached. The assumption of the model is plane remains plane. The calculation depends on a given rotation $\theta$ or $%R$ (assume $\theta = \tan \theta$) while $\varepsilon(i)$ (Strain of each element in i step) can be calculated by Equation 1 and 2.
2.2 Proposed concrete constitutive model

A simple cyclic stress-strain relation of concrete was proposed. The model is based on the envelop curve of modified Kent & Park model whereas the stiffness of cyclic compressive is initial elastic modulus of concrete as shown in Figure 5. For the first part, the ascending parabola is expressed by the following Equation 4 (before peak of line 1 in Figure 5).

\[ \sigma = k \cdot f' \cdot \left[ \frac{2 \varepsilon_c}{\varepsilon_{ek}} - \left( \frac{\varepsilon_c}{\varepsilon_{ek}} \right)^2 \right] \]

where \( \varepsilon_c \) is the longitudinal concrete strain, \( f' \) is the compressive strength of concrete, \( \varepsilon_{ek} \) is the strain of unconfined concrete corresponding to \( f' \) as shown in Equation 5, and \( k \) is a confinement coefficient which is shown in Equation 6. And a commonly accepted value of \( \varepsilon_0 \) for unconfined concrete is 0.002 (0.2%).

\[ \varepsilon_0 = 0.002k \]

\[ k = 1 + \frac{\rho_s f_{ys}}{f'_{ck}} \]

Where \( \rho_s \) is the ratio of the volume of transverse reinforcement steel to the volume of concrete core, \( f_{ys} \) is the yield strength of transverse reinforcement in MPa.
For the next part (strain greater than the corresponding strain at $f_c'$), the stress-strain relationship is presented by Equation 7 (after peak of line 1 and line 6 in Figure 5).

$$\sigma = k f_c' \left[ 1 - Z (\varepsilon - \varepsilon_0) \right] \geq 0.2 k f_c' \varepsilon > k \varepsilon_0$$  \hspace{1cm} (7)

where $Z$ is the stress decreasing ratio for the confined concrete after peak stress as shown in Equations 8.

$$Z = \frac{0.5}{3 + 0.29 f_c' + 0.75 \rho_y \frac{|h'|}{s_h} - 0.002k}$$  \hspace{1cm} (8)

In Equation 8, $s_h$ is the center to center spacing of hoop sets, and $h'$ is the width of concrete core measured to the outside of stirrups.

![Figure 5. The concrete model (Sinthaworn, 2015)](image)

In order to simulate the cyclic loading, the hysteresis unloading and reloading rules were proposed (line 2 and 5 in Figure 5) by the authors as shown in Equations 9 and 11.

$$\sigma = 0 \hspace{1cm} \varepsilon \geq \varepsilon_h$$  \hspace{1cm} (9)

$$\sigma = E_c \left[ (\varepsilon - \varepsilon_h) \right] \hspace{1cm} \varepsilon < \varepsilon_h$$  \hspace{1cm} (10)

$$\varepsilon_h = \varepsilon_{\text{min}} - \frac{\sigma_{\text{min}}}{E_c}$$  \hspace{1cm} (11)

where $\varepsilon_h$ is the strain at the reversal point, $\varepsilon_{\text{min}}$ is historical minimum strain, $\sigma_{\text{min}}$ is stress at historical minimum strain, $E_c$ is elastic modulus of concrete.

3. Model verification. Comparison with test results

3.1 Geometric Modeling

The beam reinforcing steel bars of PRC3 are 8-D19, and prestressing bars (PC) are 4-ϕ26 mm. (data from Moriguchi, 2013). For the geometric modeling, the size of concrete element is 25 mm width, while each steel bar is represented by one element. The elements and cross section of the analyzed post-tension beams are shown in Figure 6.

The initial stresses of all elements were computed based on the equilibrium of tension force of prestressed wires and compression force of concrete and mild steels. Strain of concretes and strain...
of mild steel were assumed equal. While, bond between concrete and mild steel was assumed to be perfect bond by using the equal plastic hinge length in the concrete and mild steel elements whereas bonding between concrete and prestressed tendon was un-bond by using the total length of prestressed wire as the plastic hinge length of prestressed element.

3.2 Comparison with test results and Comparison with other cyclic constitutive models

Menegotto & Pinto steel model is used in this section. All concrete models used the envelop curve from modified Kent & Park model (Chang et al., 2004). However, author model (Sinthaworn, 2015) which is based on the stiffness of cyclic compressive uses initial elastic modulus of concrete. The second model is Kent & Park. In order to simulate the cyclic loading, the hysteresis unloading and reloading rules were used as proposed by Kent and Park (1971).

And Yassin without tension model used the hysteresis unloading and reloading rules by Yassin’s model. The effect of cyclic constitutive models of concrete is shown in Figure 7. From the results, three concrete models show more or less the same values. It could be concluded that the simple cyclic hysteresis unloading and reloading rules as the proposed model (as shown in Figure 5) can capture the hysteresis relationship between lateral shear and drift angle for unbond prestressed concrete beam.

Table 1 summarizes the maximum capacity and drift angle at maximum point in order to compare the experimental results with the fiber model results. The results reveal that maximum capacities (Q) from the fiber model are close to the test data (both positive and negative sides). The
The maximum of those errors is approximately 4%. However, the drift angles at the maximum points have some errors (13%). Therefore, it could be concluded that the fiber model is capable to analyze the un-bond post tension beams with a good accuracy in a maximum capacity and the fiber model could capture a quite well lateral load - drift angle relationship (backbone curve). In addition, %R accounted flexural drift only whereas shear and pull-out were not include.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Max Q (kN)</th>
<th>at %R</th>
<th>Min Q (kN)</th>
<th>at % R</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRC3</td>
<td>Experiment</td>
<td>472.78</td>
<td>1.05</td>
<td>-472.78</td>
</tr>
<tr>
<td>Fiber model</td>
<td>490.30</td>
<td>0.99</td>
<td>-456.30</td>
<td>-1.19</td>
</tr>
<tr>
<td>% Error</td>
<td>3.71</td>
<td>-5.71</td>
<td>-3.49</td>
<td>13.33</td>
</tr>
</tbody>
</table>

Table 1 summarizes the maximum capacity and drift angle at maximum point.

Figure 10 Comparison between experiment and backbone curve from fiber model.

4. Concluding remarks

A simple model for the simulation of the response of concrete subjected to cyclic loadings has been presented. The model can reproduce the complex behaviour of unbonded post-tensioned concrete beam under tested cyclic loading. The model has been validated by comparing the results with a test (flexure behavior). The proposed model shows satisfactory agreement with the experimental result (PRC3). The comparison of the effect of cyclic rule on cyclic constitutive models of concretes shows that three concrete models (Kent and Park, Yassin, and Author model) provide the similar results. Therefore, the proposed simple cyclic rule (Author model) can be used for fiber analysis in order to simulate the cyclic behavior and backbone curve of prestressed beam. However, this model should be more properly calibrated to further experiment data in the future.

5. Acknowledgments and Legal Responsibility

The authors express them gratitude to Japan International Corporation Agency (JICA) for the financial support and Thailand International Corporation Agency (TICA), Ministry of Foreigner Affairs, Thailand for providing the opportunity of the fellowship.

6. References

Proceedings of the 13th World Conference on Earthquake Engineering, Vancouver, Canada.


Information Engineering (1)/ Computer Science (1)

Tuesday, May 10, 2016  15:15-17:15  Room 1007

Session Chair: Prof. Dyah Erny Herwindiati

ICEAI-987
Development of an Integration Surgical Special Chart Platform for Colorectal Cancer
Sheng Hsuan Hsiao | Ming Chuan University
Chia Chun Hsieh | Ming Chuan University
Ming Liang Hsiao | Taipei Veterans General Hospital
Shung Haur Yang | Taipei Veterans General Hospital
Shih Tsang Tang | Ming Chuan University

ICEAI-988
Cloud-Based Sit-to-Stand Assistant for Stroke Patients
Jyh Rou Liu | Ming Chuan University
Kuei-Hung Tseng | Ming Chuan University
L.Y. Chen | Taoyuan General Hospital
W.K. Lee | Taoyuan General Hospital
S.T. Tang | Ming Chuan University

ICEAI-1001
Smart Corpus Collector Basing on Cloud Structure
Huei Lin Jiang | Ming Chuan University
Hsin Ju Tsai | Ming Chuan University
Jen Dar Lee | Ming Chuan University
Wen Jet Wang | National Taiwan University
Shih Tsang Tang | Ming Chuan University
ICEAI-1015
An Information System for Integrating the Biochemistry and Diet
Ciou-Jyu Liao | Ming Chuan University
Yen-Jung Chiu | Ming Chuan University
Tsui-Fang Li | Kang Chiao Bilingual Primary School
J.H. Lin | Kun Shan University
Shih Tsang Tang | Ming Chuan University

ICEAI-1038
Integration of Mobile Phone and Networking Technology for Parkinson’s Disease in Dysphagia and Dysarthria
Shin Yi Guo | Taipei Medical University
Chi-Fen Chang | National Taiwan University Hospital
Chun-Hwei Tai | National Taiwan University Hospital
Hung-Wen Chiu | Taipei Medical University
Shih-Tsang Tang | Ming Chuan University

ICEAI-1189
Minimum Vector Variance Using Projection Approaches for Mining Outliers
Dyah Erny Herwindiati | Tarumanagara University
Janson Hendryli | Tarumanagara University
Rahmat Sagara | Tarumanagara University

ICEAI-1230
A DWT Based Reversible Watermarking for Image Authentication
Piyu Tsai | National United University
Meng-Po Tzeng | National United University
Chien-Hao Chiu | National United University
Yu-Syuan Liu | National United University

ICEAI-1280
Face Range Image Dataset: Acquisition, Processing and Evaluation
Parama Bagchi | RCC Institute of Information Technology
Koushik Dutta | Jadavpur University
Debotosh Bhattacharjee | Jadavpur University
Mita Nasipuri | Jadavpur University
ICEAI-987
Development of an Integration Surgical Special Chart Platform for Colorectal Cancer

S.H. Hsiao\(^a\), C.C. Hsieh\(^b\), M.L. Hsiao\(^c\), S.H. Yang\(^{d,e}\), S.T. Tang\(^f\)

\(^a\)Department of Biomedical Engineering, Ming Chuan University, Taiwan
E-mail address: frank8347@gmail.com

\(^b\)Department of Biomedical Engineering, Ming Chuan University, Taiwan
E-mail address: lulu02282003@gmail.com

\(^c\)Division of Experiment Surgery, Department of Surgery,
Taipei Veterans General Hospital, Taiwan
E-mail address: kingby4784@gmail.com

\(^d\)Division of Colon and Rectal Surgery, Department of Surgery,
Taipei Veterans General Hospital, Taiwan

\(^e\)Department of Surgery, Faculty of Medicine, School of Medicine,
National Yang-Ming University, Taiwan
E-mail address: yangsh@vghtpe.gov.tw

\(^f\)Department of Biomedical Engineering, Ming Chuan University, Taiwan
E-mail address: sttang@mail.mcu.edu.tw

1. Background and Objectives
In hospitals in Taiwan, information regarding a patient's medical treatment is currently stored in different systems, such as a hospital information system (HIS), picture archiving and communication system (PACS), and lab information system (LIS). Moreover, clinical data or reports are recorded as free-type text descriptions; consequently, there are inconsistencies in the clinical data, and difficulty in effective data analysis. According to Taiwan Health Promotion Administration, Ministry of Health and Welfare, the incidence of colorectal cancer has been the highest of all cancers since 2006. This study aimed to develop a data integration platform for physician to collect surgical information of patients who have undergone colon and rectal surgery, in order to improve the effectiveness of clinical data collection and analysis.

2. Methods
This research was divided into two stages, namely, system analysis and system construction. In the system analysis stage, the structure of medical records and data standards were discussed with colorectal surgeons in terms of two aspects. (1) The structure of the medical record dictates the data and the contents of medical records to be collected, which include progress notes, admission notes, operation notes, discharge summary, and the outpatient department follow up. Then, the data are classified into groups according to their attributes, such as general data, family history, preoperative evaluation, operative findings, and follow up. (2) The data standard is revised from free-type text descriptions to the selection of an item with a radio button or a checkbox type. Moreover, the content of the item menu is defined for items individually. The system construction stage involves establishment of the data integration platform. In this work, the development platform was Smart System Service of the Institute for Information Industry, Taiwan. Application programs with a web interface were developed. Moreover, Application Programming Interfaces were used to realize basic functions, including addition, editing, and deletion of data, as well as advanced features such as statistical analysis functions. The database of the platform was MySQL.
3. Results and Conclusion

At present, the system analysis has been accomplished. The contents of the structure of medical records and data standards were transferred to a special electronic chart, which is similar to a paper notebook. In addition, a PC version of the special chart software was developed for colorectal cancer. The software was provided to the colorectal surgeons to accumulate user experience data and knowledge, which would act as the basis and reference for the development of the data integration platform. Clinical data will be constantly collected during the operation of the data integration platform. Further, a colorectal cancer database will be gradually developed, which will make valuable research data available to colorectal surgeons.

Keywords: Colorectal cancer, integration platform, surgical data
ICEAI-988
Cloud-Based Sit-to-Stand Assistant for Stroke Patients

J. R. Liu\textsuperscript{a}, K. H. Tseng\textsuperscript{a}, L.Y. Chen\textsuperscript{b}, W.K. Lee\textsuperscript{b}, and S.T. Tang\textsuperscript{a}
\textsuperscript{a}Department of Biomedical Engineering, Ming Chuan University, Taoyuan, Taiwan
\textsuperscript{b}Department of Rehabilitation, Taoyuan General Hospital Ministry of Health and Welfare, Taoyuan, Taiwan
Email address: annie03081994@gmail.com

1. Background and Objectives
The number of patients with stroke markedly increases in an aging society. Rehabilitation is the only treatment option to recover patients from dysfunction. Sit-to-stand is not only one of the most commonly performed functional movements in daily life but also an indicator of independent living. Therefore, in this study a smartphone application was developed, which can be used in combination with a cloud platform to assist patients with sit-to-stand rehabilitation and help physiotherapists follow the rehabilitation of the patient at home on a long-term basis.

2. Methods
This study was divided into two stages: the first stage was to develop a mobile application program and the second stage was to connect this application to a cloud platform. The related results of the first stage have been submitted to the 2015 Annual Symposium on Biomedical Engineering and Technology. This paper is to describe the second stage that focused on assisting the rehabilitation by connecting to a cloud platform and computing, analyzing, and storing the patients’ rehabilitation data collected by the front-end smartphone. The cloud platform used in this study is the smart system service (S3) of the Institute for Information Industry, which is a very comprehensive development tool. S3 facilitates the information technology process startup planning and designing of the information model Unified Modeling Language (UML) to provide a variety of application program interfaces (APIs) to enable quick environment establishment and project development. The cloud-based sit-to-stand assistant helped stroke patients place the smartphone on the third lumbar vertebra. Data of sit-to-stand movement were collected with the triaxial accelerometer and rotation vector sensor in the smartphone using the Android application. Four different scores of total movement duration, peak force, force development rate, and peak power were calculated using cloud computing and S3 as the back-end database. The interactive web was used as a platform for the physiotherapist to view the performance record.

3. Results and Conclusions
In mobile application program-assisted patient rehabilitation, related data were uploaded to the cloud platform real-time when patients completed the sit-to-stand exercise. The results were returned to the smartphone via cloud computing, thereby providing feedback with results and comments to enhance patient confidence. The physiotherapist could analyze the exercise situation of the patient at home via the cloud platform and assess and adjust the home rehabilitation program. If the smartphone is not connected to the cloud database or there is no WiFi at home, the data can be stored in the smartphone and uploaded later. Because cloud computing is dedicated to computation, the smartphone can be exclusively used for detecting patients’ rehabilitation movement, achieving the best possible accuracy using a combination of the two technologies.

Today, using cloud computing is convenient: no software installation and costly maintenance is required for the server. Furthermore, the smartphone is very popular; the built-in hardware is small in size with an improved accuracy and can acquiring real-time data. In several studies the smartphone application has been included in the concept of Internet of Things. However, there are no products with a scoring function available in the market. Therefore, the innovation of this study...
will be the future trend of medical technology.

Keywords: Stroke, rehabilitation, smartphone, cloud computing
ICEAI-1001
Smart Corpus Collector Basing on Cloud Structure

H.L. Jiang\textsuperscript{a}, H.J. Tsai\textsuperscript{a}, J.D. Lee\textsuperscript{a}, W.J. Wang\textsuperscript{b}, and S.T. Tang\textsuperscript{a}
\textsuperscript{a}Department of Biomedical Engineering, Ming Chuan University, Taoyuan, Taiwan
\textsuperscript{b}Department of Engineering Science and Ocean Engineering, National Taiwan University, Taipei, Taiwan
Email address: monsando17@gmail.com

1. Background and Objectives
Corpus is the basis of linguistic research and speech therapy. However, the process of collecting voice data to build a corpus is extremely time consuming because the data need to be rechecked many times after recording to ensure the quality and integrity. This study employs a smart phone combined with a cloud platform to develop a corpus-collecting tool. User will record voice data for the corpus via the smart phone with cloud noise reduction and filtering services to enhance the corpus quality and reduce the labor and time costs.

2. Methods
The smart phone used in this study runs on a Xiaomi Redmi Android operating system. Android Studio was used as the development tool with Java as the programming language. The cloud platform was based on Linux, and Django was used as the web framework with Python language in the back-end. Apps on the phone included SDK tools and Java 8u series along with other modules. The cloud platform included web service access, API, service broker, service agent, data storage, among other modules.

3. Results and Conclusions
The smart corpus collector developed in this study not only has a general voice recording function but also has sharing, uploading, GIS functionality, and cloud-based noise reduction among other functions. During recording, the remaining storage capacity of the phone will also be displayed. First, the smart corpus collector detects if the recording quality is poor due to environmental causes. After analyzing the sound waves, the signals before and after filtering can be compared. If there is too much noise in the corpus, the data will then be sent to the cloud platform to evaluate the surrounding background noise and determine whether there is too much noise in the recording. To determine whether the background noise causes interference, the recorded voice is first processed with normalization. Subsequently, FFT is used to convert the signal from the time domain to the frequency domain. Analysis of the range of fundamental frequency between 100Hz and 350Hz - is used to determine if the files contain human speech. The sections of the recording that contain voices will then be further processed with a band filter. Lastly, inverse FFT is used to convert the signal from frequency domain back to time domain and saved as a usable file in the corpus.

The smart corpus collector developed in this study can be used anytime to collect material to be used in a corpus. The cloud platform can not only enhance the corpus quality but also allow a large sized corpus to be saved, which help avoid the smart phone from be limited by the storage space. Users can also achieve the goals of sharing and backing up of corpus at different locations and with different mobile devices.

Keywords: Corpus, Cloud Platform, Noise Reduction, Filter

113
ICEAI-1015
An Information System for Integrating the Biochemistry and Diet

Y.J. Chiu\textsuperscript{a}, C.J. Liao\textsuperscript{a}, T.F. Li\textsuperscript{b}, J.H. Lin\textsuperscript{c} and S.T. Tang\textsuperscript{a}

\textsuperscript{a} Department of Biomedical Engineering, Ming Chuan University, Taoyuan, Taiwan
\textsuperscript{b} Kang Chiao Bilingual Primary School, General Affairs Department Nutritionist, Taipei, Taiwan
\textsuperscript{c} Department of Electronic Engineering, Kun Shan University, Tainan, Taiwan

Email address: j868589250@gmail.com

1. Background and Objectives

Biochemistry has many applications in the field of laboratory medicine. Laboratory medicine provides scientific evidence and evaluates the severity and prognosis of diseases in the medical field. It is also invaluable in mass screening and investigation of risk factors in major systemic disorders. Chronic diseases due to unhealthy diets are often related to excessive intake of fats and carbohydrates. Because individual biochemistry can reflect levels of intake, this study has used individual biochemistry to formulate diet planning and suggestions.

2. Methods

This study used an individual’s biochemistry profiles to provide personalized dietary advice. Microsoft Access was used as the primary database software for storing the types of foods in the food pyramid and the ratios of carbohydrates, fats, and proteins. Microsoft Visual Studio 2010 was used to develop an interactive webpage to link up the database in Access. Currently, to estimate the physical condition of users and provide them with dietary suggestions, biochemistry of the most common diseases, including hyperlipidemia, diabetes mellitus, and those of the liver and kidney, are included as a reference in the database. For example, people with diabetes should be cautious with carbohydrate intake and regularly monitor their calorie intakes. People with hyperlipidemia should prefer foods with low lipids and calories and avoid foods that would easily be turned into cholesterol or saturated fat. People with hepatitis should eat in smaller portions but more frequently, with a preference to low-fat, protein- and calorie-rich diet. People with inflammation of kidneys should have a low intake of protein, oils, and common salt.

3. Results and Conclusions

Based on an individual’s biochemistry, customized dietary advice was designed in this study. For example, if the fasting blood glucose is more than 126 mg/dl and a 2-hour postprandial plasma glucose level is more than 200 mg/dl, a dietary recommendation suitable for patients with diabetes mellitus would be generated. Controlled food intake is crucial in people with diabetes mellitus. Intake of carbohydrates, oils, and fats must be well-regulated, and calorie-rich foods which may cause overheating should also be avoided. Using the food pyramid as a basis, there are three types of foods related to carbohydrates. When considering the intake of calories and nutrients, a proper portion of each food should also be considered. The standard food portion used as a reference to each value in this study weighed 100 grams. The ratio between carbohydrate and protein was used as the standard for assessing the dietary recommendation for people with diabetes mellitus. The value of carbohydrate was then used to adjust the quantity (in grams) of food. For example, in a portion of grain foods, carbohydrate intake needed was 15 grams and protein intake was 2 grams, resulting in a ratio of 7.5. From a food portion weighing 100 grams, 15 grams of carbohydrate was first removed, and then, food in the top and bottom 5% range of the ratio of carbohydrate to protein of 7.5 was also removed, resulting in a total calorie range of 65–71 kcal. In addition, the ratio between milk and dairy products and carbohydrate to protein was 12:8; vegetable to protein was 5:1; fruits and carbohydrate intake was 15 grams in two daily portions; meat, beans, fish, and nuts were calculated based on the ratio of fat to protein of 5:7; fats and oils intake of 5 grams in each meal, adjusting between top and bottom 5% to maintain calories of each meal at 340–365 kcal.
kcal. Biochemistry is used as a basis for dietary recommendation in the current system. However, the inspection data is only valid for 3 months. For users who need long-term diet adjustment, regular checkup is required to ensure information accuracy. At present, biochemistry in laboratory medicine can only provide diet adjustments in a general direction. Future systems will include other types of inspection data for reference, such as the study of nutrients, to provide a more specific direction in the adjustment of more detailed food items.

Keywords: Biochemistry, Diet, Information System
ICEAI-1038
Integration of Mobile Phone and Networking Technology for Parkinson’s Disease in Dysphagia and Dysarthria

S.Y. Guo\textsuperscript{a}, C.F. Chang\textsuperscript{b}, C.H. Tai\textsuperscript{c}, H.W. Chiu\textsuperscript{a}, S.T. Tang\textsuperscript{d}\textsuperscript{*}
\textsuperscript{a}Graduate Institute of Biomedical Informatics, Taipei Medical University, Taipei, Taiwan
\textsuperscript{b}Department of Rehabilitation, National Taiwan University Hospital, Taipei, Taiwan
\textsuperscript{c}Department of Neurology, National Taiwan University Hospital, Taipei, Taiwan
\textsuperscript{d}Department of Biomedical Engineering, Ming Chuan University, Taoyuan, Taiwan
Email address: m610103008@tmu.edu.tw

1. Background and Objectives
Current treatments for Parkinson’s disease (PD) merely ease the degradation of activity abilities rather than completely cure the disease. As PD is a nonfatal disease, patients must live with the inconveniences brought by dysfunction until their deaths. The main reasons of death include aspiration pneumonia and malnutrition, which are caused by the dysphagia induced by PD. Approximately 90\% of PD patients suffer from hypokinetic dysarthria early on, and functions continue to degenerate until dysphagia appears, which then ultimately leads to death. Speech rehabilitation improves the quality of communication and social life for PD patients and effectively relieves dysphagia. However, verbal abilities cannot be improved by medication or surgery alone, and speech rehabilitation is crucial. More important than the speech therapy received at hospitals is continual practice at home. However, it has long been difficult to ensure the effectiveness of rehabilitation at home. This study combined mobile devices with networking technologies to develop a speech rehabilitation assistant for PD patients at home so as to promote continuing and effective practicing.

2. Methods
The system of the speech rehabilitation assistant contains two portions: a mobile phone and the internet part. Android Studio was used to develop the mobile phone application, and the smartphone database SQLite was also deployed. Android is widely used, claims a large market share, and offers an open operating environment as well as many free teaching resources. The internet part include the database and the Web server, the Web application was developed by ASP.NET, and Windows 7 serves as the operating system of the server, in conjunction with Internet Information Services (IIS) 7. The function of the database server is to record patient practices. PD patient can use the application to do the speech rehabilitation at home and can saving the practices data. Therapists and physicians can realize the rehabilitation conditions of their patients via the Web browser.

3. Results and Conclusions
The operation procedures of the proposed system are according with the content of home practice exercises assigned by the speech therapists. After starting the application on a mobile phone, the main menu shows the exhortations from the speech therapist regarding the conditions of previous practices. Before rehabilitation practice begins, the background noise of the surrounding environment is evaluated. If the noise surpasses the speech therapy room standard of 45 dB, the patient is advised to relocate. If the background noise is within the acceptable range, then the practice may carry on. The contents encompass loud voice exercises, phonation, and the articulation of words, two-word phrases, and articles. Once all of the exercises have been completed, patients can review their practice records and upload to the database server via the internet. On the Web browser, speech therapists and physicians can watch the patient’s practice procedures, give feedback, or compile statistics regarding practice conditions.
Dysphasia affects the lives of PD patients as well as their mental and physiological statuses. Although other speech rehabilitation applications are also available, these applications lack feedback and recording mechanisms. The purpose of the proposed system is to enable the provision of feedback as patients practiced at home, increase patient motivation, and allow practices to be recorded and uploaded to the database server. Speech therapists can therefore give individual feedback to patients based on their practice conditions and revise the practice content accordingly when the patient returns to the clinic, thereby enhancing the overall effectiveness of rehabilitation.

Keywords: Parkinson’s Disease, Dysphagia, Hypokinetic Dysarthria, Speech Rehabilitation
ICEAI-1189
Minimum Vector Variance Using Projection Approaches for Mining Outliers

Dyah E. Herwindiati\textsuperscript{a,\*}, Janson Hendryli\textsuperscript{b}, Rahmat Sagara\textsuperscript{c}
Faculty of Information Technology, Tarumanagara University, Indonesia
E-mail address: \textsuperscript{a}dyahh@fti.untar.ac.id, \textsuperscript{b}jansonhendryli@gmail.com, \textsuperscript{c}rahmat.sagara.01@gmail.com

Abstract
This paper compares two robust algorithms using kurtosis and singular value decomposition projection for mining outliers. We define the mining outliers as the labeling and testing outliers. Both robust projection algorithms work in two stages. In the first stage, the projection approaches are used for reducing the dimensionality of a dataset consisting of a large number of interrelated variables. In the next stage (the second stage), a robust covariance matrix minimizing vector variance (MVV) is used for estimation on the lower dimensional data space. The performances of both algorithms are almost similar; they have a good performance for mining outliers.

Keywords: Breakdown point, Kurtosis, Projection pursuit, Robust, SVD, Vector Variance

1. Introduction
Most datasets contain anomaly data or outliers in a various percentages. The appearance of one or more outliers will lead to distortion of sample mean and variance so it causes faulty conclusions. Outlier occurs in a dataset because of unusual events, such as experiment failures, instrument damage, human errors, natural deviations in populations, changes in behavior systems, or faults in systems.

The identification of outliers is not trivial in multivariate data case; the process is more difficult on higher dimensions. Numerous outlier detection techniques have been proposed in the data analysis. The robust approach is one of fundamental approaches of outlier detection. Rousseeuw (1985) introduced minimum volume ellipsoid (MVE) and minimum covariance determinant (MCD), and Hawkins (1994) introduced the feasible solution algorithm (FSA). The fast minimum covariance determinant (FMCD) was proposed by Rousseeuw and van Driessen (1999) and blocked adaptive computationally effective outlier nominators (BACON) was introduced by Billor et al. (2000). They developed an effective and efficient robust methods based on a minimizing of covariance matrix determinant (MCD).

The minimum covariance determinant (MCD) is a robust high breakdown point and it has an important an important role in the application of data mining. The MCD is created by a famous multivariate dispersion, which is the generalized variance (GV). The lack properties of MCD is that determinant of covariance matrix equals to zero does not certainly implies that a random vector $\hat{X}$ is of degenerate distribution in the mean vector $\hat{\mu}$, and MCD also requires that the covariance matrix must be non singular. To overcome those problems, Herwindiati et al. (2007) proposed the minimum vector variance (MVV). The MVV is a robust of high breakdown point and has faster computational time than the Fast MCD.

The contribution of this paper is to study the performance of two robust algorithms using two projection approaches, kurtosis and singular value decomposition (SVD), for mining outliers. We study two advantages of projection pursuits and robust MVV for mining outliers.

The two robust projection algorithms work in two stages. In the first stage, two projections are used for reducing the dimensionality of a dataset consisting of a large number of interrelated
variables while retaining as much variations as possible. In the second stage, we estimate robust covariance matrix minimizing vector variance (MVV) on the lower-dimensional data space of two decomposition projections for mining outliers.

The projection algorithm is a beneficial tool for identifying multivariate outliers hidden in a large data set. The reduced dimensionality data consisting of large variation is very sensitive to outliers that the existence of a single outlier could significantly distort the location estimator.

2. Projection Approaches for Multivariate Data

The difficulties of multivariate data analysis involved in fitting models, estimating parameters, or clustering and classification of outliers hidden in a dataset. In one or two dimensions, outliers are easily identified from a simple plot. The problems become more difficult on higher dimensions.

Projection pursuit is a technique for finding important characteristics from lower dimensional projections of high P-dimensional multivariate data (Friedman and Tukey (1974)). Projection pursuit uses a projection index, a function computed on a projected dataset, to measure interesting values.

Our paper discusses the interesting properties of projection pursuit and the power of robust estimation for outlier detection. The purpose of our projection approach is to reduce the data dimensionality by finding a new smaller set of variables for finding outliers. Dimensionality reduction is the transformation of high dimensional data into a meaningful representation of reduced dimensionality.

We have a new data with the largest possible variance and retaining the most of the data information by two orthogonal transformations, i.e. kurtosis and singular value decomposition (SVD) projection.

2.1 Projection Using Kurtosis

Kurtosis is a parameter that describes the shape of a random variable’s probability distribution. Normal distribution produces a kurtosis statistic of about zero. A positive kurtosis indicates heavy tails and peakedness relative to the normal distribution, whereas negative kurtosis indicates light tails and flatness.

Kurtosis can be formally defined as the standardized fourth population moment about the mean,

\[
K = \frac{E((X - \mu)^4)}{(E((X - \mu)^2))^2} = \frac{\mu_4}{\sigma^4}.
\]

where \(E\) is the expectation operator, \(\mu\) is the mean, \(\mu_4\) is the fourth moment about the mean, and \(\sigma\) is standard deviation. The role of kurtosis is a measure of normality, in issues of robustness, outliers, and bimodality.

Herwindiati et al. (2015) introduced robust kurtosis projection inspired by Pena Prieto (2001). The paper explained how to find an orthonormal set of all vectors such that the kurtosis of projected data on to space spanned by each vector in that set is maximum.
Let \( X = (x_1, x_2, \ldots, x_n)' \) be a data matrix of size \( n \times p \) as the observation result of \( p \)-variables to \( n \) individuals or objects and \( \vec{d} \) a unit vector in \( \mathbb{R}^p \). The orthogonal projection of each observation result on to one dimensional space spanned by \( \vec{d} \) is \( y_i = \vec{d}' x_i \). Write the projected data as \( \tilde{y} = (y_1, y_2, \ldots, y_n) \). The kurtosis of the projected data is formulated as

\[
K = \frac{\frac{1}{n} \sum_{i \in \mathbb{N}_n} (y_i - \bar{t})^4}{s^4}
\]

(2)

where \( \bar{t} = \frac{1}{n} \sum_{i \in \mathbb{N}_n} y_i \) and \( s^2 = \frac{1}{n} \sum_{i \in \mathbb{N}_n} (y_i - \bar{t})^2 \) are the sample mean and the sample variance of the data \( Y \), respectively. It is noted that \( s^4 \) is the square of \( s^2 \) and \( \mathbb{N}_n \) is the set of all natural numbers less than or equal to \( n \).

Algorithm: Finding \( p \) unit vector that maximizes the kurtosis

1. Input: matrix data \( X = (\tilde{x}_1, \tilde{x}_2, \ldots, \tilde{x}_n)' \) of size \( n \times p \)
2. Compute the sample mean \( \bar{\tilde{X}} \) and the sample covariance matrix \( S \) of \( X \)
   \[
   \bar{\tilde{X}} = \frac{1}{n} \sum_{i \in \mathbb{N}_n} \tilde{x}_i \quad \text{and} \quad S = \frac{1}{n} \sum_{i \in \mathbb{N}_n} (\tilde{x}_i - \bar{\tilde{X}})(\tilde{x}_i - \bar{\tilde{X}})'
   \]
3. Standardize the matrix data \( X \) such that the projected data has mean 0 and variance 1
   \[
   \tilde{y}_i = S^{-\frac{1}{2}}(\tilde{x}_i - \bar{\tilde{X}})
   \]
4. Find the first unit vector \( \tilde{d}_1 \) as the eigenvector of
   \[
   \frac{1}{n} \sum_{i \in \mathbb{N}_n} (\tilde{d}' \tilde{y}_i)^2 \tilde{y}_i \tilde{y}_i'
   \]
   corresponding to the maximum eigenvalue of that matrix
5. For \( k = 2, 3, \ldots, p \), find the \( k \)-th unit vector \( \tilde{d}_k \) as the eigenvector of
   \[
   \left( I - \sum_{j=1}^{k-1} \tilde{d}_j \tilde{d}_j' \right) \frac{1}{n} \sum_{i \in \mathbb{N}_n} (\tilde{d}' \tilde{y}_i)^2 \tilde{y}_i \tilde{y}_i'
   \]
   corresponding to the maximum eigenvalue of that matrix. The output is an orthonormal set of all vectors that maximize the kurtosis \( \{\tilde{d}_1, \tilde{d}_2, \ldots, \tilde{d}_n\} \).
6. Find the projection \( z_i = \tilde{d}' y \). Determine the minimum amount of variation that we want, defined by the new variable \( z_k \).

2.2 Projection Using Singular Value Decomposition (SVD)

SVD and principal component analysis (PCA) are the beneficial tools for research analysis data. SVD and PCA can reduce the number of dimensions in data without losing much of the information, so it can also be used for data compression.

In this paper, we develop a robust singular value decomposition projection for multivariate outlier detection. We use SVD projection on reducing the dimensionality of a dataset in order to explain as much information as possible. The projection yields will be combined to the robust algorithm.
for outlier detection. This method is motivated by robust principal component (ROBPCA) which was introduced by Hubert et al. (2005). ROBPCA is a PCA method combining two advantages of both projection pursuit and robust covariance estimation.

The singular value decomposition (SVD) of a matrix \( X_{n \times p} \):

\[
X = USV^T
\]

where \( U \) is a \( n \times n \) matrix, \( V \) is a \( p \times p \) orthogonal matrix, and \( S = \text{diag}(s_1, s_2, ..., s_p) \) is \( n \times p \) diagonal matrix with \( n \geq p \) and \( s_1 \geq s_2 \geq \cdots \geq s_p \geq 0 \). The values of \( s_i \) are called the singular values of \( X \) and they correspond to the square root of the eigenvalues of the covariance matrix. The column \( u_i \) and \( v_i \) (with \( i = 1, 2, ..., p \)) of \( U \) and \( V \) are called the left and right singular vectors of \( X \).

The outer product of SVD:

\[
X = \sum_{i=1}^{p} s_i u_i v_i^T
\]

The decompositions of two positive-definite symmetric matrices, \( XX^T \) and \( X^TX \) are

\[
XX^T = USV^TUSV^T = USU^T
\]
\[
X^TX = VSV^TUSV^T = VSV^T
\]

The interesting characteristics of both decompositions are \( X^TX \), a \( p \times p \) matrix, will have \( p \) eigenvalues and the remaining \( (n-p) \) eigenvalues of \( XX^T \) will be zeros. Next, the eigenvectors and eigenvalues for \( X^TX \) can be described as the columns of \( V \) and the square diagonal of \( S \), respectively.

Algorithm: the dimensionality reduction using SVD

7. Input: matrix data \( X = (\hat{x}_1, \hat{x}_2, ..., \hat{x}_n)' \) of size \( n \times p \)
8. Compute the singular values \( s_i \) from \( X^TX \)
9. Find the right singular vector (the column of \( V \)) by finding an orthonormal set of eigenvectors \( X^TX \)
10. To reduce the \( k \) dimensionality of the data from \( p \), \( k < p \), select \( k \) first columns of \( V \), corresponding to \( k \times k \), the maximum eigenvalues of \( X^TX \). The dimensionality reduction of the right singular vector \( V_k = \{ \hat{v}_1, \hat{v}_2, ..., \hat{v}_k \} \).
11. Find the dimensional reduction data.

3. Minimum Vector Variance with Projection Approaches

The minimum vector variance (MVV) was proposed by Herwindiani et al. (2007) as a measure for identifying multivariate outliers. The estimator MVV for the pair \((\mu, \Sigma)\) is the pair \((T_{MVV}, C_{MVV})\) giving minimum vector variance.
The MVV is the robust measure emerged since Djuhari (2005) proposed the new multivariate dispersion, which is vector variance (VV). Geometrically, VV is a square of length of the diagonal of a parallelepiped generated by all principal components of $\tilde{X}$.

Suppose $\tilde{X}$ is a random vector and $\Sigma$ is the covariance matrix. If $\lambda_1 \geq \lambda_2 \geq \cdots \geq \lambda_p \geq 0$ are the eigenvalues of $\Sigma$ with size $p \times p$, then $VV = Tr(\Sigma) = \lambda_1 + \lambda_2 + \cdots + \lambda_p$, $CD = |\Sigma| = \lambda_1 \lambda_2 \cdots \lambda_p$ and $VV = Tr(\Sigma^2) = \lambda_1^2 + \lambda_2^2 + \cdots + \lambda_p^2$.

Regarding the formula, VV will be zero when all variables are of zero variance. This means that $VV = 0$ absolutely shows that $\tilde{X}$ is of degenerate distribution at $\mu$. Other good properties of VV are:

1. VV does not require nonsingular covariance matrix. This is different from CD.
2. Computations of VV are very efficient. The efficiency of VV is of order $O(p^3)$, compared to CD using Cholesky decomposition which is of order $O(n^3)$.

The MVV estimator has a high breakdown point, i.e. $\frac{(n-2)(p-1)}{2n}$, and the estimator also gives an affine equivariant property because it is not influenced by affine transformation (Herwindiati et al., 2007). The robust Mahalanobis distance between $\tilde{X}_i$ and $T_{MVV}$ in metric $C_{MVV}$, written as $dR_{MVV}(\tilde{X}_i, T_{MVV})$, can be used as a measure for outliers identification. The distance is defined in form of square as

$$dR^2_{MVV}(\tilde{X}_i, T_{MVV}) = (\tilde{X}_i - T_{MVV})^T C_{MVV}^{-1}(\tilde{X}_i - T_{MVV}), i = 1, 2, ..., n$$  \hspace{1cm} (5)

### 3.1 The Algorithm of MVV with Kurtosis Projection

Herwindiati et al. (2015) introduced Robust Kurtosis Projection. The method combines the good properties of kurtosis projection pursuit and the power of robust estimation. Robust kurtosis projection has a good performance and robustness when detecting data contamination in a low, moderate, high, and even very high percentage.

The algorithm works in two stages. In the first stages, we propose the projection approach to find the orthonormal set of all vectors that maximizes the kurtosis of the projected standardized data. This approach improves on the slow convergence rate of Pena and Prieto (2001). In the second stage, we estimate robust covariance matrix minimizing vector variance (MVV) to label high dimensional outliers.

**Algorithm: MVV with Kurtosis Projection**

1. Find the orthonormal set of all vectors that maximize the kurtosis $\{\tilde{d}_1, \tilde{d}_2, ..., \tilde{d}_p\}$ (see the algorithm in Section 2).
2. Compute MVV robust estimators; the location and scale estimator.
   a. Determine input data
   b. Let $H_{old}$ be an arbitrary subset containing $h = \left\lfloor \frac{n+k+1}{2} \right\rfloor$ data points.
      Compute the mean vector $\overline{x}_{H_{old}}$ and covariance matrix $S_{H_{old}}$ of all
      observations belonging to $H_{old}$. Then compute,
      $dR_{MVV}^2(x_i, T_{MVV}) = (\overline{x}_i - T_{MVV})^T C_{MVV}^{-1} (\overline{x}_i - T_{MVV})$
      for all $i = 1, 2, ..., n$.
   c. Sort these distances in increasing order
      $d^2_{H_{old}}(\pi(1)) \leq d^2_{H_{old}}(\pi(2)) \leq \cdots \leq d^2_{H_{old}}(\pi(n))$.
   d. Define $H_{new} = \{\overline{x}_{\pi(1)}, \overline{x}_{\pi(2)}, ..., \overline{x}_{\pi(k)}\}$.
   e. Calculate $\overline{x}_{H_{new}}, S_{H_{new}}$, and $d^2_{H_{new}}(i)$.
   f. If $Tr(S^2_{H_{new}}) = 0$, repeat step 1 to 5.
      If $Tr(S^2_{H_{new}}) = Tr(S^2_{H_{old}})$, the process is stopped.
      Otherwise, continue until $k_{th}$ iteration if
      $Tr(S^2_{k}) \geq Tr(S^2_{k-1}) \geq \cdots \geq Tr(S^2_{1}) = Tr(S^2_{k+1})$.

3.2 The Algorithm of MVV with SVD Projection
We use SVD projection to reduce the data dimensionality and find a new smaller set of variables
for detecting outliers. We see that singular value decomposition (SVD) and principal component
(PC) analysis are two eigenvalue methods used to reduce a high dimensional dataset into lower
dimensions while retaining the essential characteristics of information. Furthermore, the SVD and
the eigen decomposition are closely related. The eigenvectors of the covariance matrix of
principal component are the same right singular vectors of SVD.

Hubert et al. (2005) proposed ROBCA which is a fast and robust algorithm for PCA of high
dimensional data. The idea of ROBPCA is application of MCD estimator for lower dimensional
data space. ROPCA is the robust high breakdown point and it has a good performance in
computational time. Tiwari and Sora (2014) proposed a novel compression combining digital
image watermarking scheme based on singular value replacement technique, which is robust
against image processing distortions and geometrical attacks. The technique is used for protected
digital multimedia content.

We compose the algorithm of MVV with SVD projection in two stages. In the first stage, we do
the dimensionality reduction using SVD. Meanwhile, in the second stage, we compute MVV
robust estimators, the location and scale estimator.

4. The Experiments for Mining Outliers
In this section, we do the experiment for mining outliers (labeling and testing outliers). The
labeling of outliers means that we separate a dataset in two categories, a clean and suspected data.
The testing of outliers is a process to test whether the suspected outliers are outliers.
For the experiments, we generate a simulation data of size $n$ from a mixture model with a high percentage of outliers. The model is $(1 - \epsilon)N_p(\mu_1, \Sigma) + \epsilon N_p(\mu_2, \Sigma)$ where $n = 1000$, $p = 50$, and with a high percentage of contamination $\epsilon = 0.30$.

The two robust projections will run on two stages. The first stage is for reducing the dimensionality of the data, and in the second stage we estimate the robust covariance matrix minimizing vector variance (MVV) on the lower dimensional data space for mining the outliers (the labeling and testing outliers). The outlier labeling can be considered as the early procedure to get the information of "suspects". The performance of outlier labeling will be illustrated in the following figures.

Figure 1: Labeling outliers using robust MVV-Kurtosis projection

Figure 2: Labeling outliers using robust MVV-SVD projection

The figures show surprising result. Both algorithms of robust projection have good performance when identifying the 'suspects' or labeling the outliers. The 'suspects' can be separated clearly from the good data.

In the next stage (testing stage), we determine a cut off point for a decision rule to accept or reject the labeled outliers as outliers. The theoretical cutoff will be considered.
Let $\tilde{X}_1, \tilde{X}_2, \ldots, \tilde{X}_n$ be a random sample drawn from $N_p(\mu, \Sigma)$ where $\Sigma$ is definite positive. We denote $G$ the group of ‘good’ observations and its complement $G^c$ is the group of labeled outliers. Let also $\tilde{\mu}_G$ and $\tilde{S}_G$ represent the mean vector and covariance matrix of all sample items belong to $G$, and $\text{Card}(G^c) = k$. Thus,

$$\tilde{\mu}_G = \frac{1}{n-k} \sum_{i \in G} \tilde{X}_i \quad \text{and} \quad \tilde{S}_G = \frac{1}{(n-k)-1} \sum_{i \in G} (\tilde{X}_i - \tilde{\mu}_G)(\tilde{X}_i - \tilde{\mu}_G)^t$$

To test whether $G^c$ really consists of all outliers, let $\nu_i = \left(\tilde{X}_i - \tilde{\mu}_G\right)^t \tilde{S}_G^{-1} \left(\tilde{X}_i - \tilde{\mu}_G\right)$ for all $\tilde{X}_i \in G^c$. Then, $\tilde{X}_i$ is declared outlier at level of significance $\alpha$ if $\nu_i \sim \frac{p(n-k-1)(n-k+1)}{(n-k)(n-k-p)} F_{p,n-k-p}$.

**Theorem.** Let $\tilde{X}_1, \tilde{X}_2, \ldots, \tilde{X}_n$ be a random sample of size $n$ from $N_p(\mu, \Sigma)$ where $\Sigma$ is definite positive, and $\tilde{\mu}$ and $\tilde{S}$ represent the sample mean vector and sample covariance matrix. $\tilde{X}_i$ is independent from $\tilde{\mu}_G$ and $\tilde{S}_G$ for all $\tilde{X}_i$ in $G_C$. To investigate the exact distribution of $\nu_i$, we use the following theorem (Mardia et al. (1979)):

$$(n-1) \left(\tilde{\mu} - \mu\right)^t \tilde{S}^{-1} \left(\tilde{\mu} - \mu\right) \sim \frac{p(n-1)}{n-p} F_{p,n-p}$$

Based on this theorem, it can be proved that the exact distribution of the statistical test $\nu_i$ is

$$\nu_i \sim \frac{p(n-k-1)(n-k+1)}{(n-k)(n-k-p)} F_{p,n-k-p}$$

Regarding our simulation experiment on labeling stage, we will test whether the suspects (labeled outliers) are ‘outliers’. To conduct the testing stage, we compute the cut off $\nu_i = 45.7611$. Relying on the value of cutoff $\nu_i$, we see that the suspects are far away from the cutoff $\nu_i$. It means that the labeled outliers are truly outliers.

**5. Breakdown Point**

Breakdown point is one way to measure robustness. The purpose of robustness is to safeguard against deviations from the assumptions (Ronchetti, 2014). Breakdown point measures how many data can be change to be infinity before they are meaninglessly crushed to bits. This paper will discuss the breakdown point from the context of a sample.
Consider the good dataset \( \bar{X} = (\bar{x}_1, \bar{x}_2, ..., \bar{x}_n) \) and the statistics is 
\[ T_n(X) = T_n(\bar{x}_1, \bar{x}_2, ..., \bar{x}_n). \]

Assume the contaminated dataset \( \bar{X}^* = (\bar{x}_1, \bar{x}_2, ..., \bar{x}_{n-m}, \bar{x}_{n-m+1}^*, \bar{x}_{n-m+2}^*, ..., \bar{x}_n^*) \) and the contaminated value is \( T_n(\bar{X}^*) \). Rousseeuw and Leroy (1987) defined breakdown point for sample of size \( n \) as follows
\[
\varepsilon_n^*(T, \bar{X}) = \min \left\{ \frac{m}{n} \mid \text{bias}(m, T, \bar{X}) \text{ infinite} \right\}
\]
where the bias is defined as \( \text{bias}(m, T, \bar{X}) = \sup_{\bar{X}'} \| T_n(\bar{X}^*) - T_n(X) \| \).

A primary goal of robust statistics procedure is the development of procedures which are still reliable and reasonably efficient under small deviations from the model (Ronchetti, 2014).

To indicate the power of both robust projection methods, we use simulation data for breakdown point. The following figures illustrate the robustness of both approaches. The figures show that MVV using kurtosis projection has higher breakdown point than SVD approach, but MVV using SVD projection is more stable than kurtosis projection.

![Figure 3: The breakdown point of MVV using Kurtosis projection](image3)

![Figure 4: The breakdown point of MVV using SVD projection](image4)

6. Conclusion
Robust minimum vector variance using kurtosis and SVD projection are the effective measures to solve a research problem for mining outlier with a highly redundant information between variables. The empirical result provide that both robust projection algorithms can be considered for the applications of dimensionality reduction technique with outliers hidden in the data set.

References


ICEAI-1230
A DWT Based Reversible Watermarking for Image Authentication

Piyu Tsai*, Meng-Po Tzeng*, Chien-Hao Chiu*, Yu-Syuan Liu*
*Department of Computer Science and Information Engineering, National United University, Taiwan
Email address: pytsai@nuu.edu.tw

Abstract
Image authentication is concerned for image is becoming another text form in our living. In this paper, a DWT based reversible watermarking for image authentication is proposed. The higher relationship between DWT transformed image coefficients is explored to achieve the watermark embedding/extraction with reversibility. The watermark for image authentication is embedded according to the histogram shifting based algorithm. The experimental results show the performance of the proposed scheme that the original image can be recovered. Any modification to the watermarked image can be detected by comparing the embedded and original watermark. Furthermore, the tampered areas can be detected and located correctly.

Keywords: Watermarking, image authentication, reversible

1. Background/ Objectives and Goals
The promoted digital technology has changed the usage of digital divides in users. Nowadays, the traditional pen writing is replaced by camera in mobile phone. The image is becoming another text form. People takes the camera image as the memo. Students use camera image to replace the class note. Furthermore, these images are distributed on the Internet to share with others. However, the security issues such as forgery, tampering as well as others are more concerned. To resolve image communication security, several approaches are proposed [1-2].

To protect image communication security, the proposed approaches can be classified into digital signature-based and watermarking-based [3]. Digital signature-based authenticator preserves the integrity of original multimedia and the signature (watermark) must be stored to an extra space. On the watermarking-based approach, the original media content is modified to insert the watermark and no extra space is required to store the watermark.

Generally, the watermarking-based approach is more difficult to reduce the embedding distortion and to enhance the detection senility. Furthermore, the watermarked-based authenticators can be divided into fragile and semi-fragile watermarking according to their robustness. In fragile watermarking authenticator, any slight modification to the watermarked media is detected. On the other hand, the semi-fragile watermarking permits some general-image operations and only malicious operations such as object insert/delete are detected.

In addition, the watermarking-based approach can be classified into reversible and irreversible according to the original media can be reconstructed or not. Today, reversible watermarking is more concerned for the original media is preferred and required in applications such as medical, law and military, etc.

Several reversible watermarking for data hiding have been proposed. In Ni. et al. scheme [4], the pixel histogram of an image is generated and the peak and zero points are selected. The image pixel value is examined to determine the data hiding. When the hidden data is extracted, the original image can be reconstructed completely. In Tsai et al. scheme [5], the image is divided into non-overlaid blocks. The central pixel of the block pixels is subtracted to other pixels to create a
difference block. The differences of all of blocks are calculated and statically to generate histograms. By shifting the block difference to embed the data in which the hiding capacity is improved.

A few of reversible watermarking for image authentication was proposed. In Meenakshi Devi et al.'s scheme [6], the watermark is first embedded in spatial domain to verify authenticity and then is embedded in discrete wavelet transform (DWT) domain provides reversibility. Both techniques: selective LSB embedding and histogram shifting are utilized. In [7], their scheme is based on histogram modification on integer wavelet transform (IWT) domain. The coefficients in high frequency sub-bands are statistical and employed to embed the watermark according to the histogram modification scheme. In [8], a semi-blind reversible pixel-wise image authentication is proposed. This scheme can authenticate images and locate tampered areas. Also exact recovery of the original image is possible.

In this paper, a reversible watermarking for images authentication with less embedding distortion and more detection sensitivity is proposed. The rest of this paper is organized as follows. In Section 2, the histogram shifting based data hiding scheme is briefly described. In Section 3, the proposed scheme is introduced. The experimental results are shown in Section 4. Finally, some conclusions are given in Section 5.

2. The Histogram Shifting Based Data Hiding Method

The methods section is usually the second-longest section in the abstract. It should contain enough information to enable the reader to understand what was done, and important questions to which the methods section should provide brief answers. The histogram shifting based data hiding scheme was proposed by Ni et al. [4]. They explore the distribution of image pixel values and then statistically calculated the occurrences of all possible image pixel values to obtain a histogram. A peak and zero points are indicated with the maximum and the zero/minimum occurrences in histogram, respectively. The peak and zero points are paired \( P(p, z) \) and taken as an indicator to achieve the reversible data hiding.

To achieve the reversible data hiding, the \( P(p, z) \) must be determined before embedding procedure is performed. In the embedding procedure, each image pixel is examined with \( P(p, z) \) to determine which is located in one of three cases. In the first case, the image pixel equals to the peak point, this pixel will be used to carry a data bit. If the data bit to be embedded is 0, this pixel is preserved. Otherwise, the embedded data bit 1 is encountered, this pixel must shift one location in direction to zero point. In this case, the data can be inserted into image. In the second case, the pixel located between the peak and zero points \( P(p, z) \). In this case, this pixel is shifted one location to zero point direction and no data is hidden. In the last case, all of pixels those remain for they are nothing to do with data hiding. Equations (1) and (2) indicate the embedding cases.

\[
px' = \begin{cases} 
px + 1, & \text{if } (\text{peak} < px \leq \text{zero}) \\
px, & \text{otherwise}
\end{cases} \quad (1)
\]

\[
px' = \begin{cases} 
px + 1, & \text{if } (sb = 1) \\
px, & \text{if } (sb = 0)
\end{cases} \quad \text{if } (px = \text{peak}) \quad (2)
\]

In the extraction and recovery procedure, \( P(p, z) \) used in the embedding procedure should be known before the data extraction and recovery. Similarly, Four cases are included in this procedure. In the first case, the pixel value equals to the peak point. In this case, a hidden bit 0 is extracted and the pixel value remains. In the second case, the pixel value located between \( P(p, z) \) and equals to the peak point +1/-1, a hidden bit 1 is extracted and the pixels are shifted to the peak point by...
one location. In the third case, pixels located between $P(p,z)$ are shifted to the peak point by one location and no secret is extracted. Lastly, the remained pixels are ignored and their values remain. After that, the hidden data can be extracted and the original image is reconstructed.

### 3. The Proposed Method

The purpose of the proposed scheme is to develop a watermarking for image authentication with original recovery. The relationship of DWT transformed coefficients is explored and the histogram shifting data hiding scheme is employed to which the embedding distortion can be reduced and the original image can be reconstructed from watermarked images. Two procedures: the watermark embedding and the watermark extraction and image recovery are involved in this scheme. The flow chart of the proposed embedding and verification and recovery procedures are shown in Fig. 1.

**Fig. 1: A flow chart of the proposed method**

#### 3.1 The Embedding Procedure

The embedding procedure embeds the watermark into images with reversibility according to the histogram shifting based algorithm. To achieve the watermarking reversibility, the relationship between DWT coefficient is explored. To further enhance the embedding capacity, the coefficient difference is employed. Accordingly, the DWT coefficient difference between blocks is used in the proposed scheme.

To perform watermark embedding, the original image is first divided into blocks with size of $32\times32$ pixels which is the same as JPG 2000 decomposition size. Each block then performs DWT transformation with two levels in which seven sub-bands are generated. When all of blocks are transformed, the relationship between two neighboring blocks is exploited. The absolute coefficient difference between two blocks indicate the relationship of two blocks. Generally, the less the difference, the higher the relationship. From our experiments, it is found that lots of DWT coefficient difference is valued at smaller. In other words, the a higher relationship indicates both blocks are similar.

The coefficient difference ($diff$) of two blocks is computed according to equation 3

$$diff_i = |eff_{Ai}| - |eff_{Bi}|$$

in which $||$ is the absolute operation, $eff_{Ai}$ and $eff_{Bi}$ are the $i$-th coefficients of blocks A and B, respectively. The differences are statistical to generate one positive histogram and another negative histogram for the positive and negative difference, respectively. In our experiments, only positive histogram with one peak and zero points pair $P(p,z)$ is taken. When $P(p,z)$ is selected, the watermark used to verify the image integrity is embedded. The watermark bit stream $w=\{0,1\}$ is
generated by pseudo random number generator (PRNG). To embed the watermark, each coefficient difference is examined and modified according to equations 4 and 5.

\[
d_{i}^{'} = \begin{cases} 
    d_{i}^{'} + \pm 1, & \text{if} \ (w = 1) \\
    \frac{d_{i}^{'} + \pm 1}{2}, & \text{if} \ (w = 0) \\
    \frac{d_{i}^{'} + \pm 1}{2}, & \text{if} \ (\text{peak} < d_{i}^{'} \leq \text{zero}) \\
    \text{otherwise} & 
\end{cases}
\]

in which the \(d_{i}^{'}\) is the modified difference. The histogram shifting algorithm is employed in the watermark embedding procedure. According that, the modified difference can be recovered completely to which the reversible watermarking can be achieved.

Once all of coefficient differences are examined and watermark bits are embedded, the modified differences are re-computed to the DWT block in which one of two blocks is modified. When blocks are re-computed, the inverse DWT transformation is performed to generated watermarked images. After that, the image is watermarked and can be authenticated in the verification procedure.

### 3.2 The Verification and Recovery Procedure

The verification and recovery procedure is to verify the integrity of the received images and to reconstruct the original images from watermarked images. To verify image integrity, the embedded watermark should be extracted from the watermarked images. The watermark extraction procedure is similar to the histogram shifting based data extraction procedure. The watermarked image is divided into blocks with sized of 32×32 pixels and then performs DWT transformation. And then, the coefficient difference between two DWT blocks are computed. These processings are the same as that is employed in the embedding procedure. Each coefficient difference is detected to determine whether the watermark is embedded or not.

If the difference equals the peak point, a watermark bit 0 is extracted and the difference remained. If the difference locates between the peak and zero points and near to the peak point by one, a watermark bit 1 is extracted and the difference is shifted to the peak point direction by one location. The remained difference located between the peak and zero points are shifted to the peak point direction with one location and no watermark is extracted. The remained differences are ignored for they are nothing to do with verification and recovery processings.

When the embedded watermark is extracted and the original watermark generated by PRNG is also provided, both watermarks are compared. The watermark comparison result indicates the received image is authenticated or not. Since the watermark embedding is worked on image block, so that, if the watermark comparison of each block is mismatched, the location of both blocks in watermarked image are marked as tampered areas. From that, the tampered areas can be located according to the block location in images.

To reconstruct the original image, the recovery procedure is performed in which the coefficient difference is detected and modified in the watermark extraction processing. When all of differences are examined and recovered after the watermark extraction processing, the recovered DWT coefficients of each block performs IDWT transformation. From that, the original blocks are reconstructed completely and the original image is obtained.

### 4. The Experimental Results

To evaluate the performance of the proposed scheme, some experiments were implemented. Three gray-level images with size of 512×512 pixels were taken as the test images and shown in Figs.
These test images were first divided into blocks of 32×32 pixels. Each block is further decomposed into two levels by using DWT transformation. Then, the difference between two neighboring block DWT coefficients is computed. The difference equals 0 is selected as the peak point. The 32-bit watermark is embedded into each block. The watermark bit stream is generated by PRNG.

![Figure 2: The original and watermarked images](image)

Table 1: The distributions of coefficient differences

<table>
<thead>
<tr>
<th>Image/Difference</th>
<th>Airplane</th>
<th>Boat</th>
<th>Lenna</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>27,645</td>
<td>20,066</td>
<td>21,823</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>17,312</td>
<td>15,594</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>16,627</td>
<td>15,248</td>
</tr>
<tr>
<td>2</td>
<td>-</td>
<td>8,695</td>
<td>9,008</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>8,247</td>
<td>9,071</td>
</tr>
<tr>
<td>3</td>
<td>+</td>
<td>4,862</td>
<td>5,211</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>4,551</td>
<td>5,363</td>
</tr>
<tr>
<td>4</td>
<td>+</td>
<td>3,171</td>
<td>3,335</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>2,937</td>
<td>3,392</td>
</tr>
<tr>
<td>5</td>
<td>+</td>
<td>2,280</td>
<td>2,334</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>2,131</td>
<td>2,331</td>
</tr>
</tbody>
</table>

Table 2: The maximum and minimum numbers of each block $\text{diff} = 0$

<table>
<thead>
<tr>
<th></th>
<th>Airplane</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Airplane</td>
<td>48</td>
<td>706</td>
<td>36</td>
<td>303</td>
</tr>
<tr>
<td>Boat</td>
<td>Min</td>
<td>Max</td>
<td>Min</td>
<td>Max</td>
</tr>
<tr>
<td>Lenna</td>
<td>41</td>
<td>362</td>
<td>41</td>
<td>362</td>
</tr>
</tbody>
</table>
To evaluate the relationship of two neighboring blocks, the distributions of DWT coefficient differences are shown in Table 1. In Table 1, it is found that the number of difference equaled 0 is the largest. Furthermore, the number of difference equaled 0 in each block is compared and the minimum is shown in Table 2. From Table 2, it is indicated that each block difference provides a sufficient space to embed the watermark.

To measure the proposed embedding procedure, the watermark is embedded into the test images. Two neighboring block DWT coefficients difference is employed to determine the watermark embedding in which the \( \text{dif} = 0 \) is selected. In this experiment, 32-bit watermark is embedded into each block difference. The watermarked images were shown in Figs. 2(d-f). From Fig. 2, it is difficult to distinguish the difference between the original and watermarked images by the human eyes. In addition, the image quality of PSNR also indicates that the watermarked images still preserve a higher image quality.

To verify the image integrity, the watermarked images with no any modification is first verified. The verification results were the same as the original images and were shown in Figs. 1(a-c) in which the watermark is extracted from watermarked image and the original images were reconstructed. These results indicate that the proposed scheme preserves the function to recover the original images. To evaluate the tamper detection, the watermarked images were tampered and shown in Fig. 3. In Figs. 3(a-c), the image airplane number “01568” was changed to “1568” and an object “light tower” was inserted into the left side of image boat and texts “NUU” was inserted into image lenna. The tampered areas were marked by a circle and shown in Figs 3(a-c), respectively. The verification procedure was performed and the results were shown in Figs. 3(d-f). From Figs. 3(d-f), it is found that the tampered areas were detected and located. These results also shown that the proposed scheme can detect the malicious operations such as object insert/delete and the tampered areas can be located correctly.

![Fig. 3: The tampered and detected images](image-url)
5. Conclusions
In this paper, a reversible watermarking for images authentication is presented. The relationship of two blocks DWT coefficients is explored to obtain the similarity characteristic. The higher relationship between two blocks DWT coefficients benefits the proposed scheme to achieve the watermarking with reversibility. The experimental results also show that the original images can be reconstructed after the watermark is extracted. Furthermore, the tampered areas can be detected and located correctly. The future research of the proposed scheme will focus on reducing the size of detected tampered areas and adaptive the watermark embedding space for blocks.

6. Acknowledgments
This research was supported by the Ministry of Science and Technology, Taiwan, R.O.C. under contract 104-2221-E-239-028.

7. References
ICEAI-1280
Face Range Image Dataset: Acquisition, Processing and Evaluation

Parama Bagchi¹, Koushik Dutta², Debotosh Bhattacharjee³, Mita Nasipuri⁴

¹Assistant Professor, Dept of CSE, RCC Institute of Information Technology, Kolkata, India.
E-mail address: paramabagchi@gmail.com
²Research Fellow, Dept. of CSE, Jadavpur University, Kolkata, India
E-mail address: koushik.it.22@gmail.com
³Professor, Dept of CSE, Jadavpur University, Kolkata, India
E-mail address: debotosh@ieee.org
⁴Professor, Dept of CSE, Jadavpur University, Kolkata, India
E-mail address: mitanasipuri@gmail.com

Abstract
In this present work, a new database consisting of 3D face images acquired using David Structured Light and Kinect Camera individually is being introduced. The database is unique, because the faces captured using 3D cameras are acquired under very challenging conditions, such as varying poses, expressions, occlusions and combinations of extreme poses and occlusions, as well as combinations of expressions, occlusions, and poses. Though 3D modeling techniques have been popularly used for face recognition, barely any research on 3D data with the combined pose, occlusion and expression have been reported. The database will be soon made available to the researchers and scientists for their research purpose. Finally, a recognition system based on feature extraction by Principal Component Analysis (PCA) and classification by Multilayer Perceptron (MLP) have been developed on the 3D face images acquired using Kinect and Structured Light Cameras resulting in recognition rates of 92.86% and 97% respectively.

Keywords: David Structured Light Camera, Range Images

1. Background/ Objectives and Goals

In recent years, 3D face recognition has gained notable popularity due to its relative advantages over 2D face recognition techniques, because of extreme poses (partial data), illumination variations, expressions, and occlusions. An important application of 3D facial processing is the understanding of facial expressions, occlusions, and poses. Since 3D data works with depth information so, they can very well handle pose as well as occlusions. This trend has received impetus due to the wider availability of 3D range scanners and cameras.

Existing methods for facial feature detection and recognition assume frontal and neutral views only, and the biometric systems are designed accordingly. But, this forced posing can be uncomfortable for the subjects and can limit the application domains. In real life applications, one cannot always assume a face to be strictly frontal. So, it is highly necessary to develop algorithms working with the natural and uncontrolled behavior of subjects. For example, in real life situations, a subject may be oriented across, pose and occlusions. A face recognition system may have to handle situations where the subjects try to be recognized by posing awkwardly and worse still, by resorting to occlusions via dangling hair, eyeglasses, facial hair and other accessories. Recent developments in the field of 3D face recognition have shown that more challenging environments for the acquisition of 3D data might exist, e.g. a subject might have combined pose and occlusion(s), extreme poses, or even, a combination of pose, occlusion(s), and expression.

Under such situations, the design of a 3D face database is not an easy task. Design of such a 3D face database should contain:-
(i) Extreme single-viewed poses across yaw, pitch and roll ranging from 45 to 90°.

(ii) Occlusions like dangling hair, glasses, etc.

(iii) Facial expressions of anger, disgust, happiness, sadness which significantly changes the facial appearance of a person.

(iv) A combination of pose with occlusions

(v) A combination of pose and expressions

(vi) A combination of pose, occlusion, and expressions.

Motivated by these exigencies, a new ‘comprehensive’ 3D face database is presented here. Existing systems [1] have seen many 3D face databases that have subjects across pose, occlusions, and expressions, but the present one is unique, in the sense that, this database consists of a combination of pose, occlusions, and expressions.

The rest part of this paper is organized as follows. Section 1.1 describes some already existing 3D face databases across either pose, occlusions or expressions [8]. Data collection is described in Section 2 along with the camera details. Then, the description of the face database is detailed in Section 2.4. The experimental results of the present database have been given in Section 3. Comparative analysis of the present database over existing 3D facial databases has been given in Section 4. Finally, some conclusions along with future scope are mentioned in Section 5.

1.1 Some existing 3D face databases

Several types of research have been conducted on 3D face recognition techniques using new databases employing real-life challenges for over three decades. In [2], the authors have acquired the 3D RMA database of 120 persons but with very limited orientations of the head: straight forward, Left or Right, Upward or Downward. The Bosphorus Database [3], is another very popular database, consisting of:

(1) Facial expressions

(2) Head pose variations from 0-90°.

(3) Different types of face occlusions.

The Binghamton University 3D Facial Expression [4,7] is a database across pose and expressions. This database aimed to address both pose and expressions from 0 to 45° that are detrimental factors for 3D face recognition.

The CASIA database [5] is a 3D face database, consisting of face images with variations in either pose, or, expression, or, illumination, and also the combinations of expressions under varying illumination conditions and poses.

A summary of the existing 3D and 2D face databases has been given in Table 1. From Table 1, it
is clear that existing databases contain less challenging situations than those encountered in real life scenario. For person identification, the face image of a person may be captured with the pose, expression, and occlusion completely different from those in the face image of the same person stored in the system. So, there is a need for a new face database containing 3D face data across pose, occlusions, expressions and combinations of pose, occlusion, and expression that are quite natural in real life.

Table 1. Summarization of the existing 3D and 2D face databases across various pose, occlusions, and expressions

<table>
<thead>
<tr>
<th>Database Type</th>
<th>Name of the Database</th>
<th>Number of subjects</th>
<th>Capturing of face images under various input situations</th>
</tr>
</thead>
</table>
| 3D Face Databases | Bosphorus database | 105 subjects | 1. Pose variations of 0-90°
2. Occlusions, expressions on frontal pose only. |
| | GavabDB database | 61 subjects | 1. Poses across 0-80°
2. Expressions on frontal pose only. |
| | 3D_RMA database | 120 subjects | 1. Only pose with limited orientations of the head. |
| | BU-3DFE database | 100 subjects | 1. Pose and expressions ranging from -45° to +45° |
| | Eurecom Kinect face dataset | 52 subjects | 1. Different facial expressions
2. Different lighting conditions
3. Different occlusion conditions |
| 2D Face Databases | CAS-PEAL Database | 1040 subjects | 1. Poses from 0 to 90° across yaw and pitch
2. Expressions
3. Pose and expressions
4. Occlusions
5. Pose and occlusions
6. Lighting
7. Pose and lighting
8. Variation of background |

The present 3D face database contains face images of 100 individuals (captured using Kinect and DAVID Structured Light Cameras) with 72 different images per individual taken in different poses, with different expressions and occlusions and also with different combinations of pose, expression, and occlusion.
2 Methods: Creation of the 3D Face Database

For capturing the 3D facial scans across combined pose, occlusion, and expressions, data were collected using two different modern 3D scanners namely David Structured Light (SLS-1) and Kinect.

2.1. Data Acquisition

To capture the 3D face database, the Biometric Lab of Jadavpur University was chosen. The lab is well illuminated to capture images of individuals. Fig-1 shows the lab setup for the face data acquisition. Facial data are acquired using two different scanners namely DAVID Structured Light (SLS-1) camera and Kinect camera. The details of these two cameras are given in the following sections.

![Fig1. Setup of the lab where data acquisition process was held](image)

2.1.1 David Structured Light Camera (SLS-1): - Structured Light Scanners (SL) uses a video projector instead of a laser DAVID uses the video projector to project some stripe patterns onto the object. The camera will take (at least) one image of each pattern. Based on these stripe patterns, DAVID will generate a 3D mesh of the object. Camera calibration is the same as for laser scanning. Scanning, however, is much faster and simpler. Calibration panels can be removed after camera and projector calibration. Advantage of David Structured light scanning is:

- No moving parts
- One click only
- Scan takes only a very few seconds
2.1.2 **Kinect Camera:** -Kinect was chosen to be one of the scanners because it can capture a face in less than a second. Subjects were made to sit at a distance of about 78 cm away from the 3D scanner. The room is well lit up to obtain homogeneous lighting. In this phase data is also segmented manually by selecting a polygonal face region. Finally, each scan is down-sampled and saved in two separate files that stores color photographs and 3D coordinates. A segmented 3D face approximately consists of 35K points. The advantage of Kinect is because of its ease of use and inexpensive nature.

2.1.3 **Details of database creation process**

Mostly students, faculties, and office staffs of Computer Science and Engineering department of Jadavpur University have participated in this database creation process. Also, ex-students of the University, as well as Ph.D. scholars, have already given their consent to be a part of this database. Since the total number of face images to be captured is 72, the entire session takes close to 1 hr 25 mins. Subjects have been told to sit still during each session. The construction of this database has already started. Each subject has been told to give pose from frontal to 45°, 60°, 90° in each orientation. Among expressions, subjects have been asked to render surprise, happy, sadness, disgust, fear as well as anger. For facial occlusions subjects have been asked to occlude their faces with glasses, handkerchiefs, facial hair and hand. Also, a combination of the above poses, expressions as well as occlusions has also been used. In total, the database would finally consist of 14,400 facial scans across very challenging combined pose, occlusions, and expressions that are indeed a magnificent number.

2.2 **Description of the 3D Facial database**

The present database aims to capture 3D facial scans of 100 individuals. The entire set consists of 72 images per person using each of the cameras, Kinect, and DAVID SLS-1.

In total, six variations of pose, occlusion, and expressions of the images have been applied to construct the present database:-

A. **Pure-Pose Variation:** -To capture images with varying poses, the subject is asked to look in extreme direction i.e. (45 to 90 degrees across yaw), across pitch (30 degrees) and roll (30 degrees).

B. **Expression Variation:** -In addition to the neutral expression, six various expressions like happy, sad, surprise, disgust, fear, and anger was asked to render by the subjects.

C. **Occlusion Variation:** - Four different occlusion variations such as occlusion of mouth and eye by hand, occlusion due to the presence of hair, glasses were considered.

D. **Occlusion and Pose Variation Combined:** - Using a combination of B and C above the images were captured.

E. **Oclusions with rotated pose and expressions:** -The faces were occluded, and in addition to that, they were rotated across poses and asked to render expressions. In this way, the face images were captured.

F. **Expressions with Rotated Pose:** -The subjects were asked to render expressions along
with rotated poses.

After the data from Structured Light and Kinect cameras are obtained in the form of \((x, y, z)\) coordinates, they are first saved as .obj file format. Table 2 shows a description of the subjects. Next, they are subjected to a two-step pre-processing stages namely, data processing and range image conversion.

- **Data processing:** to make the database useful for assessing and comparing algorithms for recognition of 3D face images with varying pose, occlusion, and expression, we provide the 3D data in the database. Since the raw geometric face models contain the head-shoulder boundaries including necks and clothing, which may be considered as outliers, so they are eliminated using DAVID SLS cropping tool.

- **Range Image conversion:** After the raw data has been neatly cropped, they are further processed by converting to range images. A range image also called a 2.5D image, is a 2D image with intensity value at \((x, y)\) pixel position of the image is proportional to the depth at that point. 3D raw data must be converted to a range image, for it to be further processed either for face registration and recognition. The range images have been shown above in Fig 3 for reference purpose.

Fig 2. Sample Range images with varying pose, occlusions and expressions
<table>
<thead>
<tr>
<th>Category A</th>
<th>Category B</th>
<th>Category C</th>
<th>Category D</th>
<th>Category E</th>
<th>Category F</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Frontal-1</td>
<td>(a) Anger</td>
<td>a) Occlusion of Mouth</td>
<td>a) Occlusion of eyes with 45 L</td>
<td>a) Expression of anger with 45L</td>
<td></td>
</tr>
<tr>
<td>b) Frontal-2</td>
<td>(b) Surprise</td>
<td>b) Occlusion of eyes</td>
<td>b) Occlusion of eyes with 60 L</td>
<td>b) Expression of anger with 60L</td>
<td></td>
</tr>
<tr>
<td>c) Rotated Left (45 Deg)</td>
<td>(c) Disgust</td>
<td>c) Occlusion of Glasses</td>
<td>c) Occlusion of eyes with 45R</td>
<td>c) Expression of anger with 45R</td>
<td></td>
</tr>
<tr>
<td>d) Rotated Left (60 Deg)</td>
<td>(d) Fear</td>
<td>d) Occlusion of Hair</td>
<td>d) Occlusion of eyes with 60R</td>
<td>d) Expression of anger with 60R</td>
<td></td>
</tr>
<tr>
<td>e) Rotated Left (90 Deg)</td>
<td>(e) Happy</td>
<td>e) Occlusion of mouth with 45L</td>
<td>e) Occlusion of eyes with 45L and expression disgust</td>
<td>e) Expression of surprise with 45L</td>
<td></td>
</tr>
<tr>
<td>f) Rotated Right (45 Deg)</td>
<td>(f) Sad</td>
<td>f) Occlusion of mouth with 60L</td>
<td>f) Occlusion of eyes with 45R and expression disgust</td>
<td>f) Expression of surprise with 60L</td>
<td></td>
</tr>
<tr>
<td>g) Rotated Right (60 Deg)</td>
<td>(g)</td>
<td>g) Occlusion of mouth with 45R</td>
<td>g) Expression of surprise with 45R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>h) Rotated Right (90 Deg)</td>
<td>(h)</td>
<td>h) Occlusion of mouth with 60R</td>
<td>h) Expression of surprise with 60R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i) Pitch Up</td>
<td>(i) Occlusion of Glasses with 45L</td>
<td>i) Occlusion of Glasses with 45L</td>
<td>i) Expression of disgust with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>j) Pitch Down</td>
<td>(j) Occlusion of Glasses with 60L</td>
<td>j) Occlusion of Glasses with 60L</td>
<td>j) Expression of disgust with 60L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>k) Roll (Z axis left)</td>
<td>(k) Occlusion of Glasses with 45R</td>
<td>k) Occlusion of Glasses with 45R</td>
<td>k) Expression of disgust with 45R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>l) Roll (Z axis right)</td>
<td>(l) Occlusion of Glasses with 60R</td>
<td>l) Occlusion of Glasses with 60R</td>
<td>l) Expression of disgust with 60R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>m) Occlusion of hair with 45L</td>
<td>m) Occlusion of hair with 45L</td>
<td>m) Occlusion of hair with 45L</td>
<td>m) Expression of fear with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>n) Occlusion of hair with 60L</td>
<td>n) Occlusion of hair with 60L</td>
<td>n) Occlusion of hair with 60L</td>
<td>n) Expression of fear with 60L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>o) Occlusion of hair with 45R</td>
<td>o) Occlusion of hair with 45R</td>
<td>o) Occlusion of hair with 45R</td>
<td>o) Expression of fear with 45R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>p) Occlusion of hair with 45R</td>
<td>p) Occlusion of hair with 45R</td>
<td>p) Occlusion of hair with 45R</td>
<td>p) Expression of fear with 60R</td>
<td></td>
<td></td>
</tr>
<tr>
<td>q) Expression of happy with 45L</td>
<td>q) Expression of happy with 45L</td>
<td>q) Expression of happy with 45L</td>
<td>q) Expression of happy with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r) Expression of happy with 60L</td>
<td>r) Expression of happy with 60L</td>
<td>r) Expression of happy with 60L</td>
<td>r) Expression of happy with 60L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>s) Expression of sad with 45L</td>
<td>s) Expression of sad with 45L</td>
<td>s) Expression of sad with 45L</td>
<td>s) Expression of sad with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>t) Expression of sad with 60L</td>
<td>t) Expression of sad with 60L</td>
<td>t) Expression of sad with 60L</td>
<td>t) Expression of sad with 60L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>u) Expression of sad with 45L</td>
<td>u) Expression of sad with 45L</td>
<td>u) Expression of sad with 45L</td>
<td>u) Expression of sad with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v) Expression of sad with 60L</td>
<td>v) Expression of sad with 60L</td>
<td>v) Expression of sad with 60L</td>
<td>v) Expression of sad with 60L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>w) Expression of sad with 45L</td>
<td>w) Expression of sad with 45L</td>
<td>w) Expression of sad with 45L</td>
<td>w) Expression of sad with 45L</td>
<td></td>
<td></td>
</tr>
<tr>
<td>x) Pitch up with open mouth and closed eye</td>
<td>x) Pitch up with open mouth and closed eye</td>
<td>x) Pitch up with open mouth and closed eye</td>
<td>x) Pitch up with open mouth and closed eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xi) Roll right with open mouth and closed eye</td>
<td>xi) Roll right with open mouth and closed eye</td>
<td>xi) Roll right with open mouth and closed eye</td>
<td>xi) Roll right with open mouth and closed eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xii) Roll right with open mouth and closed eye</td>
<td>xii) Roll right with open mouth and closed eye</td>
<td>xii) Roll right with open mouth and closed eye</td>
<td>xii) Roll right with open mouth and closed eye</td>
<td></td>
<td></td>
</tr>
<tr>
<td>xiii) Roll left with open mouth and closed eye</td>
<td>xiii) Roll left with open mouth and closed eye</td>
<td>xiii) Roll left with open mouth and closed eye</td>
<td>xiii) Roll left with open mouth and closed eye</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Details of the subjects


3 Evaluation of the Database

3.1 Feature Extraction: To recognize the individuals by classifying them, feature extraction based on principal component analysis is used, which is the most traditional one. PCA is probably the most widely used subspace projection technique for face recognition. PCA basis vectors are computed from a set of training images ‘I’. As a first step, the mean image in ‘I’ (I_{mean}) is computed and subtracted from the training images, creating a set of data samples i_1, i_2,,...,i_n where i_1, i_2,,...,i_n are the training samples. These data samples are then arrayed in a matrix X, with one column per sample image.

\[
X = \begin{bmatrix}
\vdots & \vdots & \vdots \\
i_1 & \cdots & i_n \\
\vdots & \vdots & \vdots 
\end{bmatrix}
\]

Next, the covariance matrix is calculated by performing XX^T. Then the eigenvectors of the covariance matrix are calculated, sorted in descending order, and the largest 20 eigenvectors are used for feature extraction. The feature vectors are then classified using Multilayer Perceptron[13]. The architecture for the MLP used has been shown in Fig 4. The design of a neural network involves designing classes that would train positive as well as negative examples. The output of such a network would be 1 or 0, 1 if the test sample belongs to that particular class and 0 if it does not. So, to train a network, the following architecture as stated in D.Bhattacharjee et al.[14] has been implemented.

![Fig 3. Structure of Multi-Layer Perceptron](image-url)

8
3.2 Experimental Results: - Table 3 shows the recognition rates obtained on the 3D face images acquired using Kinect and Structured Light cameras using feature extraction by PCA (Principal Component Analysis) and classification by Multilayer Perceptron [13]. For each face database, from each class, we took 18 images from the chosen class as positive examples for training, and the rest 18 images from the same class for testing. These 18 images were chosen randomly from each face database were across pose, occlusions or even expressions. For each group, an equal number of images from other classes were chosen randomly as negative examples for training and testing. At first principal component analysis is employed to extract features and then Multilayer Perceptron is employed for classification.

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Databases Used</th>
<th>Training: Test ratio size</th>
<th>Classifiers used</th>
<th>Recognition rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Database acquired using Structured Light</td>
<td>1:1</td>
<td>MLP</td>
<td>92.86%</td>
</tr>
<tr>
<td>2.</td>
<td>Kinect database</td>
<td>1:1</td>
<td>MLP</td>
<td>97%</td>
</tr>
</tbody>
</table>

4 Comparative Analysis

Table 4 shows a comparative analysis of the various databases used for biometric purposes and proves how the present database excels than all of the existing 3D and 3D video databases. A clear comparison shows how the present database captured across pose, occlusions, and expressions regarding evaluation, the number of subjects and the challenges handled in the present database regarding its content.

<table>
<thead>
<tr>
<th>Already Existing 3D Face Datasets across pose/expressions/occlusions</th>
<th>Total no. of subjects in the dataset</th>
<th>Content of the dataset</th>
<th>Evaluation results regarding recognition obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>BU-3DFE (L. Yin, X. Wei, Y. Sun, J. Wang, M. Rosato et al, 2006)[4]</td>
<td>100 adults</td>
<td>Six basic expressions at 4 intensity levels</td>
<td>The correct recognition rate is about 83.6% using LDA.</td>
</tr>
<tr>
<td>Database Name</td>
<td>Number of Adults</td>
<td>Number of AUs</td>
<td>Basic Expressions</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>------------------</td>
<td>---------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>2D+3D dataset recorded with 3D sensor (Tsalakanidou et al (2010)). [11]</td>
<td>52</td>
<td>11</td>
<td>6 basic expressions</td>
</tr>
<tr>
<td>3D Video Data (Benedikt et al. 2010) [12]</td>
<td>94</td>
<td>11</td>
<td>Smiles and word utterance</td>
</tr>
<tr>
<td>3D Deity Jadavpur University Face Database</td>
<td>100</td>
<td>3</td>
<td>3D face images across pose, occlusions and expressions as well as a combination of pose, occlusions and expressions.</td>
</tr>
</tbody>
</table>
5 Conclusion and Future Scope

In this present work, a new 3D face database across pose, occlusions and expressions has been introduced. The present database is sure to excel regarding its real life applications and regarding biometric modality. The justifications and the need for designing such a complicated database have been clearly defined as well as justified. Various strategies, processes, as well as the need for designing such a database, are truly justified, and the evaluation results also show the extent to which the database can recognize subjects. As a part of future work, the registration, as well as recognition of various feature extraction technique, would be tried on this database. Thus, a thorough evaluation of this database has been kept as a part of the future work.

Acknowledgment

The work has been supported by the grant from DeiTy, MCIT, Govt. of India.

References


Environmental Sciences (2)

Wednesday, May 11, 2016 08:45-10:15  Room 1006

Session Chair: Prof. Jiun-Horng Tsai

ICCBES-1221
Quantifying Transboundary Contribution of Particulate Matter and Particulate Polycyclic Aromatic Hydrocarbons for a Tropical Coastal Area in the East Asian Pacific Rim Region
Chon-Lin Lee | National Sun Yat-sen University
I-Chien Lai | National Sun Yat-sen University
Hu-Ching Huang | National Sun Yat-sen University

ICCBES-1096
Meteorological Analysis for the Protected Horticulture Complex in Saemanguem Reclaimed Land, South Korea
Minjung Park | National Academy of Agricultural Science
Donghyeon Kang | National Academy of Agricultural Science
Siyoung Lee | National Academy of Agricultural Science
Jongku Kim | National Academy of Agricultural Science
Hongki Choi | National Academy of Agricultural Science
Jinkwan Son | National Academy of Agricultural Science

ICCBES-1097
Bio-Ore of Silicon, Rice Husk: Its Use for Sustainable Community Energy Supply based on Producing Amorphous Silica
Masafumi Tateda | Toyama Prefectural University

ICCBES-1117
Developing an Air Cleaner for Photodegradation of Formaldehyde and Optimize the Design Parameters by CFD Modeling
Yun Ching Leong | National Taiwan University
Chen Kang Huang | National Taiwan University
ICCBES-1130
Assessment of the Possibility of Enhanced Cs Uptake by Plants under Conditions of Severe Potassium Deficiency and Radioactive Stress, Utilizing Microorganisms and Bio-Energy-Activators
Archil Archil Chirakadze | Georgian Technical University
Ramaz Akaki Gakhokidze | Javakhishvili Tbilisi State University
Archil Giorgi Chogoshvili | Georgian Technical University
Zakaria Elguja Buachidze | Georgian Technical University

ICCBES-1193
Characterization of Air Pollutants Emissions from Motorcycle under ECE and WMTC Driving Modes by Using Ethanol-Blended Gasoline
Jiun-Horang Tsai | National Cheng Kung University
Yung-Chen Yao | Industrial Technology Research Institute
I-Ting Wang | National Cheng Kung University
Hsuan-Chi Huang | National Cheng Kung University
ICCBES-1221
Quantifying Transboundary Contribution of Particulate Matter and Particulate Polycyclic Aromatic Hydrocarbons for a Tropical Coastal Area in the East Asian Pacific Rim Region

I-Chien Lai, Chon-Lin Lee, Hu-Ching Huang
Department of Marine Environment and Engineering, National Sun Yat-sen University
linnohc@mail.nsysu.edu.tw

Abstract
A conceptual quantitative procedure was developed, and an atmospheric pollutant concentration baseline was established to investigate the transboundary transport contribution of atmospheric pollutants in the study area. Five representative transport pathways were classified, and three source regions were identified: East Asia, Southeast Asia, and Taiwanese cities. The average contributions during the two-year observation from the predominant source region, which is the East Asian continent, accounted for 41.8%, 38.9%, 52.5%, and 53.6% of PM$_{10}$, PM$_{2.5}$, BaP, and sixteen PAHs, respectively. In terms of health issues, the average contributions of particulate matter (PM$_{10}$ and PM$_{2.5}$) were between 44.2–56.6% for heavy pollution days (PM$_{10}$ concentration $> 125 \mu g m^{-3}$) and 44.6–59.4% for health-effect days (PM$_{10}$ concentration $> 150 \mu g m^{-3}$), respectively. Regarding PAHs, the average contributions were 49.3–63.6% and 45.2–57.0% for heavy pollution days and health-effect days, respectively. This quantitative method provided an alternative approach for studying the transboundary transport impact on receptors.

Keyword(s): Back trajectory; East Asia; Atmospheric pollutant; Pollutant source region

1. Introduction
Many studies have demonstrated that atmospheric pollutants can be exported from their source regions to different continents, even on a global scale [1]. Recently, small size particles (PM$_{2.5}$) have been receiving increased attention because of their relatively high risk for daily mortality and the long-term risk of death [2]. Some studies have pointed out that fine particles can be transported for longer distances than coarse particles (e.g., PM$_{10}$). In our previous studies, a clear seasonal variation of PAHs was found in the Kaohsiung coastal area, and the suggested transboundary transport of air pollutants from neighboring areas may be sources of high PAH concentrations during the winter. These researches provided relevant information that transboundary pollutant transport from various source regions may affect human health and air quality in the study area.

Kaohsiung, located in the southern region of Taiwan, is an industrial and harbor city. Air
quality is mainly influenced by industrial activities (e.g., petrochemical, steel, and electronics industries), coal-fired power plants, and urban traffic emissions. Based on meteorological conditions, Kaohsiung is a typical subtropical city under the influence of the Asian monsoon system with distinct wet and dry seasons in summer and winter, respectively. Because of its location and climatic features, the source, transport pathway, and concentrations of PAHs in the atmosphere of Kaohsiung city may be affected by land-sea circulations, maritime airflows, and air-water exchange processes. In our previous studies [3], we found a clear seasonal variation of PAHs in the Kaohsiung coastal area, in particular for high PAH concentration observed in winter, may be associated with long-range transport of air pollutants from neighboring area. The aim of this study is to identify the relationship between seasonal variation of PAH concentration and long-range transport based on two years observation data.

2. Main Body

In this study, we found that particulate matter pollution in the study area should be considered seriously for the air quality management, due to the annual average concentrations of PM\textsubscript{10} and PM\textsubscript{2.5} both exceeded the Taiwan EPA annual limit values. With respect to PAHs, the statistical results suggests that the effects of BaP on human health in the study area was not exceeded the standard set by European Union during the study period. The correlation between atmospheric pollutants (PM\textsubscript{10}, PM\textsubscript{2.5}, and PAHs) and meteorological conditions indicates that the concentrations of atmospheric pollutants could increase with decreasing ambient air temperature. The correlation with wind direction suggested that transboundary pollutant transport from northeasterly direction and local emission from urban area are important sources for the study area. Based on two years back trajectory analysis, we illustrated six representative transport pathways, two local emission types and four transboundary transport contribution types. The source regions for the study area can be classified in three categories: East Asia, Southeast Asia and Taiwan cities. The dominant source region of transboundary contribution to the study area is East Asia region, particularly from China (Type BE). The contribution from this source region accounted for 37%, 34%, 42% and 43% of PM\textsubscript{10}, PM\textsubscript{2.5}, BaP and sixteen PAHs, respectively. The contribution from other cities in Taiwan is also a major source for the study area. There were about 12% of PM\textsubscript{10} and 11% of PM\textsubscript{2.5}, 12% of BaP and 12% of sixteen PAHs contribution attributed to this source region, respectively. The results of transport pathways identification and the estimation of atmospheric pollutant contribution from different source regions in this study underlined the importance of transboundary transport contribution in local air quality management.

2.1 Figures and Tables
Fig. 1. Time series plots of observed six particle PAH concentrations (dotted line) and total suspended particulates (TSP, solid line).

Table 1. Pearson correlation coefficients of six particulate PAHs with meteorological parameters and total suspended particulates. Correlation statistics (n=52).

<table>
<thead>
<tr>
<th></th>
<th>6 PAHs (ng/m³)</th>
<th>TSP (µg/m³)</th>
<th>Temp (°C)</th>
<th>Pressure (hpa)</th>
<th>RH (%)</th>
<th>Wspeed (m/s)</th>
<th>Wdirection (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 PAHs (ng/m³)</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSP (µg/m³)</td>
<td>0.67**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>-0.78**</td>
<td>-0.59**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pressure (hpa)</td>
<td>0.59**</td>
<td>0.62**</td>
<td>-0.77**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RH (%)</td>
<td>-0.48**</td>
<td>-0.28</td>
<td>0.54**</td>
<td>-0.52**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wspeed (m/s)</td>
<td>0.07</td>
<td>0.03</td>
<td>0.05</td>
<td>-0.32</td>
<td>0.11</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wdirection (°)</td>
<td>-0.03</td>
<td>-0.22</td>
<td>0.11</td>
<td>-0.26</td>
<td>-0.03</td>
<td>0.10</td>
<td>1</td>
</tr>
</tbody>
</table>

** Correlation is significant at the 0.01 level (2-tailed).
2.2 Acknowledgments and Legal Responsibility

The authors acknowledge the financial support from the National Science Council and the Ministry of Education of Taiwan, R.O.C., under Contract Numbers NSC 100-2611-M-110-010 and NSC 101-2611-M-110-012.

3. References

the southwestern coastal area of Taiwan – with a GMDH approach, Journal of Environmental Management, 2013, 115(0), 60-68.
Meteorological Analysis for the Protected Horticulture Complex in Saemanguem Reclaimed Land, South Korea

Minjung Park*, Donghyeon Kang, Siyoung Lee, Jongku Kim, HongKi Choi, Jinkwan Son
National Academy of Agricultural Science, RDA, South Korea
mjpark0107@korea.kr

1. Background/Objectives and Goals
South Korea has been reclaiming a lot of land. The reclamation area in Saemangeum is the largest in Korea. It is suitable for a large-scale horticulture complex. Therefore, the climate of the reclaimed land will be instrumental in selecting the area. This selected sites is energy lowered so that agriculture can be sustained.

2. Methods
The study sites include regions around the Saemangeum area, in which the development of an industrial complex extending 28,300 ha has been planned. We collected meteorological data from 12 sites, established a rating scheme, and developed thematic maps. We selected ten themes by consulting experts using a questionnaire. The ten selected themes are Summer, 20 days max. temp. mean; Winter, 20 days min. temp. mean; Summer, 90 days temp. mean; Winter, 90 days temp. mean; Year-round, max. wind velocity; Year-round, wind velocity mean; Winter, 90 days solar radiation mean; Year-round, number of foggy days; Year round, 1 day max. rainfall; and Spring, 90 days humidity mean. Additionally, we set ratio-based weights for the evaluation parameters. The increase in Korea’s agricultural productivity has proportionally accounted for the horticulture industry. This advantage can improve Korea’s position in the international competition for agricultural productivity. Therefore, large-scale horticulture is required.

3. Expected Results/Conclusion/Contribution
In the thematic maps for the mean and peak temperatures in summer, the southwestern coastal region was found to be cooler than the northeastern inland region, and thus, received a higher rating. The winter temperature distributions also revealed that the coastal region is more advantageous compared with the eastern inland region. High-speed winds were observed to blow from the southwestern direction. The inland region received a higher rating for the amount of insulation during the winter months because of the influence of sea fog and mist in the coastal region. Special care was necessary in reflecting the precipitation factor for the planning, construction, and management of the risk of land subsidence in the study sites. According to the thematic maps based on mean humidity during the spring months, the mean humidity ranged from 63% to 72%, and the humidity conditions were thus verified to offer a
suitable environment for vegetation, as presented in a previous study. By overlapping the thematic maps, we extracted the regions that scored 50–59 points as suitable sites for the development project. Of these pre-selected sites, we selected the final candidate for protected horticulture by overlapping the sites selected for agricultural and living environment construction. The results of this study will add value by minimizing the environmental management costs for horticulture and landscaping. The operation of a large-scale protected horticulture and landscaping project in the Saemangeum Complex will enhance the agricultural competitiveness of our country in the global market.

Acknowledgements
This study was carried out with the support of "Research Program for Agricultural Science & Technology Development (Project No. PJ070970)", NAAS, RDA, Republic of Korea.

Keywords: Overlay, GIS, Landscape Architecture, Greenhouse, Design, Ecosystem Service
Bio-Ore of Silicon, Rice Husk: Its Use for Sustainable Community Energy Supply based on Producing Amorphous Silica

Masafumi Tateda, Ph.D.
Department of Environmental Engineering, Toyama Prefectural University, Japan
tateda@pu-toyama.ac.jp

Keywords: Rice husk, biomass energy supply, heat collection, sustainable system

1. Background/ Objectives and Goals

Once seen not just as waste but as a burden to dispose of, rice husk now offers new hope to Asian countries for sustainable biomass energy. The key to creating a sustainable energy supply system is to use a production-scale boiler to ash containing amorphous silica that can be returned to rice paddies as fertilizer.

The objective of this paper is to introduce the concept of a sustainable energy/agriculture system that uses rice husk as biomass fuel and then returns the rice husk to the field as fertilizer. This recycles the silica and saves money compared to the use of kerosene; thus the system is both biophysically and economically sustainable. Figure 1 shows our conceptual model.

The rice husk byproduct is burned in a carefully controlled boiler system from which the heat is collected. The by-product of this process is an amorphous material composed of 95% silica. Since the silica in the ash is amorphous, it dissolves in water and can be returned as fertilizer to flooded rice paddies. It is a regenerative cycle: the rice absorbs the silica, grows, is harvested, and the winnowed rice husk is incinerated, with the predominantly silicic ash being returned once again to the rice. The same cycle can be repeated over and over, which is why our system is considered biophysically sustainable (Figure 1).
2. Methods

a. Rice Husk Supply
Rice husk generated by a local agricultural association was used as a fuel for an energy supply system. The water content of the rice husk was usually 10-13%.

b. Location of an Energy System was Installed
A rice processing factory belonging to the same local agricultural system was selected as the site of the experimental energy facility. The factory was equipped with storage silos, a drying facility, a milling facility, and rice husk storage yards. About 600 tons of rice husk is generated by this factory annually and has been disposed of as industrial waste, costing several tens of thousands of dollars yearly. The disposal cost is, in fact, a heavy burden to a small agricultural association.

c. Analysis of Amorphous Silica
The physical properties of the silica in the rice husk ash was analyzed by X-ray fluorescence (XRF: Smart Lab 9kW, RIGAKU, Cu-Kα. 2θ:5-80°).

d. Analysis of Solubility of Amorphous Silica
The solubility of the amorphous silica was measured by the sodium hydroxide (NaOH) method, which is closely related to the Japanese Standard for Fertilizer Measurement Analysis (Japanese Hiryo Torishimari Regulation 4.1.1.c) that is also called as the potassium fluoride (KF) method.

2.5 Measuring the effect of Silica Fertilizer on Rice Plant Growth
To assess the effect of the silica in the rice husk ash on plant growth, Wagner pots (size 1/2000 a) were used to grow of Koshihikari (Oryza sativa L.) or one of well-known Japanese variety of rice. The “a” means “are” and means 100 m². The solubility of silica in the ash was calculated as 40%.

3. Expected Results/ Conclusion/ Contribution

3.1 Essential Consideration: Amorphous Status of the Silica
To be useful as fertilizer, the silica in the rice husk ash must be amorphous; there is no value if the silica is crystalized. Figure 2 shows a result of an XRF analysis; there is no indication of cristobalite and trydemite, thus we conclude that the silica is amorphous.
3.2 Solubility of the Silica
The solubility of the ash was approximately 50% (Figure 3).

3.3 Results of Fertilization Experiment for Rice Plants
The efficacy of the ash fertilizer was demonstrated by the plant growth experiment described in Section 2.5. Figure 4 shows visually that the fertilized rice plant grew better than the plant without the ash.

3.4 Evaluation of the Sustainability of the Community Energy System
An economic evaluation was done for the energy system, which is economically sustainable only when the system has a positive net benefit. Figure 5 shows the details of the energy system; if the ash were not sold, it would no longer be economically sustainable. Consequently, the silica in the rice husk ash must be sold for materials such as fertilizer. Rice husk can be considered a bio-ore of silicon, but to make the bio-ore valuable as fertilizer, the silica in the ash must remain amorphous. Therefore, an incineration technique that leaves the silica in the ash in an amorphous state is essential.
From this case study, we conclude the following:

1. To use rice husk sustainably, one very good option is to incinerate it to produce useful heat
and to use the ash as fertilizer.

2. For the ash to be used as fertilizer, the silica in the ash must be amorphous.

3. To produce amorphous silica ash, it is critical that incineration of the rice husks be carefully controlled.

4. Through the incineration process, both waste heat and CO₂ can both be recovered and used effectively for other processes such as greenhouse food cultivation.

5. The amorphous silica potentially has several uses.

Japan’s staple, rice, can now be viewed as a sustainable source of biomass, using the rice husk as an energy source and the ash for fertilizer or other uses. Whereas rice husk has been seen as not just waste but as a burden to dispose of, it now offers new hope for sustainable biomass energy systems for not only Japan but also other Asian countries.

4. References

Developing an Air Cleaner for Photodegradation of Formaldehyde and Optimize the Design Parameters by CFD Modeling

Yun-Ching Leong*, Chen-Kang Huang
Department of Bio-Industrial Mechatronics Engineering, National Taiwan University, Taiwan
r03631046@ntu.edu.tw

1. Background/ Objectives and Goals
People stay indoor most of the time, optimizing indoor air quality becomes increasingly important. Sources of indoor air pollution come from chemicals from building materials, outdoor air pollutants, gases from fireplaces, cleaning supply chemicals, etc. People may have Sick Building Syndrome (SBS) or Building Related Illness (BRI) when staying long in a polluted indoor environment. Therefore, we designed a photocatalytic reactor with high photodegradation efficiency.

2. Methods
Photocatalyst preparation: a mixture of 12 g TiO$_2$ P25 nano-powder, 36 mL distilled water and 1 mL Triton X-100 was stirred for 2 hr, added 3g 200 mesh active carbon subsequently and stirred to uniform.

Photocatalytic reactor: figure 1 shows the cyclone photocatalytic reactor that was used in this study. Photocatalyst aqueous mixture was applied on the inner surface of the cyclone with surface area 0.184 m$^2$. UV-irradiation with four 254nm UV lamps, each lamp had an intensity of 3.81 m W/cm$^2$.

Procedure: A certain amount of formaldehyde solution was dropped into a sampling chamber (725L) to volatile, stayed 30 min to reach uniform distribution. Switched on the UV lamps until
the photodegradation attained saturation state. During the experiment, the concentration of formaldehyde and CO$_2$ was measured by Formaldemeter htv-m (PPM Technology Ltd., England) and CO$_2$ Meter 1370 (TES Electrical Electronic Corp., Taiwan), respectively.

3. Expected Results/ Conclusion/ Contribution

The result of photodegradation of formaldehyde is shown in figure 2a. The concentration of formaldehyde decreases from 3.257 ppm to 0.013 ppm after UV-irradiation for 160 min, while the generation of CO$_2$ during photocatalytic increases from 508 ppm to 576 ppm. Also, it can be seen that the concentration of CO$_2$ is slightly decreases before 40 min, and maintains at 499 ppm, the concentration begins to increase after 20 min. It proves that once formaldehyde entered the cyclone, it was first adsorbed by active carbon until saturated, then diffused to TiO$_2$ surface to proceed photocatalytic oxidation reaction. Besides, the photocatalyst have a capability of CO$_2$ adsorption. From figure 2b, it shows the cyclone photocatalytic reactor has good photodegradation efficiency even at low initial concentration. The concentration of formaldehyde decreases from 0.074 ppm to 0.031 ppm after UV-irradiation for 356 min, CO$_2$ maintains at 576 ppm after 368 min, which means that the photocatalytic oxidation reaction has reached saturation.

Figure 2. Photodegradation of formaldehyde at (a) $C_{in} = 3.257$ ppm (b) $C_{in} = 0.074$ ppm.

Preliminary results of CFD modeling (Fluent 16.1) of the cyclone photocatalytic reactor are displayed in figure 3. According to the working principle of cyclone separator, the flow pattern inside the cyclone will maintain a swirling motion, this high swirling motion may increase the air residence time, and high residence time can increase the photodegradation efficiency. From
figure 3b, it shows the air flows recirculating inside the cyclone photocatalytic reactor.

Figure 3. (a) Velocity profile for air flow inside the cyclone photocatalytic reactor. (b) Particle tracking in cyclone photocatalytic reactor.

Keywords: Photodegradation of formaldehyde, indoor air quality, CFD modeling of cyclone
Assessment of the Possibility of Enhanced Cs Uptake by Plants under Conditions of Severe Potassium Deficiency and Radioactive Stress, Utilizing Microorganisms and Bio-Energy-Activators

Archil Chirakadze, Ramaz Gakhokidze, Archil Chogoshvili, Zakaria Buachidze

Background/ Objectives and Goals

The experience of almost six decades shows that the increase of potassium content in soils has been the most effective means to prevent the uptake of cesium by plants and, hence, to suppress the radioactive contamination of food. A group of Georgian researchers proposed and preliminary studied the novel concept with a view to solve the “inverse” problem aimed to decrease the potassium content in soils and significantly enhance the uptake of cesium by plants up to the levels sufficient for effective phytoremediation. A special objective is also the enhancement of vital functions and the acceleration of metabolism of plants under conditions of strong potassium deficiency (“potassium starvation”) which is necessary for effective phytoremediation. This paper also deals with the methods of processing waste newly generated due to phytoremediation of contaminated soils (the so called “phytoremediation waste”).

Methods

Different methods were applied as follows. Modelled soils with four different content of potassium and three different levels of contamination by $^{137}$Cs were prepared; sugar-beet and red beet, greenery and field grasses were cultivated in pots with modelled soils; Effective microorganisms (EM) preparations, different phyto-hormones and bio-energy activators were added to enhance vital functions and accelerate the metabolism of the plants. The corresponding changes in vegetation parameters, yield and quality of crops, chemical content and radioactivity of soils and plants were studied and analyzed. The influence of this combined
application of EM preparations, phyto-hormones and bio-energy-activators on the uptake of cesium by the plants, and the total efficiency of phytoremediation were studied, analyzed and systematized. Vacuum distillation of harvested beet followed by composting of distillation bard, harvested greenery and grasses, and biogas production using the composted waste were applied for environment-friendly utilization of the obtained “phytoremediation waste”, using both convenient and microwave heating. Chemical and radioactivity analysis, weighing of all obtained products, as well as energetic analysis of alcohol and biogas were carried out. The residual that could not be classified as very low level radioactive waste (VLLW) or exempted waste was removed from the biogas reactor and disposed of into containers for storage of radioactive materials.

**Expected Results/ Conclusion/ Contribution**

The increased uptake of Cs by plants, characterized by the transfer factor TF ≥ (30÷50, in comparative units) was observed when the content of available potassium in soils was below $N_K = 50 \, \mu M$, and practically vanished at levels $N_K \geq 200 \, \mu M$, depending on the type of plant and radioactivity of soils. The total efficiency of phytoremediation strongly depended on the amount of EM preparations, phyto-hormones and bio-energy-activators added to the soils. The radioactivity of the alcohol produced using vacuum distillation of the sugar beet (1-2 Bk/kg) was near the detection limit. Vacuum distillation showed a number of fundamental advantages and provided a purified product substantially free of undesirable impurities (such as acetaldehyde). The creamy substance containing 32-36% crude protein gave essentially a concentrated yeast bard ready for final drying or direct use in the compost mass to produce biogas. Radioactivity of this mass was about 10 to 12-times lower than the initial crops. Radioactivity of biogas obtained from the compost mass containing alcohol bard and green mass of “phytoremediation plants” was below the detection limit. Radioactivity caused by $^{137}\text{Cs}$ in fertilizers produced from bards was 150-200 Bk/kg, which is twice lower than the level permitted for fertilizers to be used in Japan. Radioactivity of $^{137}\text{Cs}$ in livestock feed containing up to 10% of feed additives produced from bards was below 200 Bk/kg, which was about 2-times lower than the level for brown rice permitted in Japan. Less than 10% of the harvested plant mass used for phytoremediation is expected to undergo special management as radioactive waste after the application of the above methods. We expect to reduce this value to less than 2% using microwave heating which significantly accelerates the chemical reactions and increases the efficiency of processing.

**Keywords:** $^{137}\text{Cesium}$, phytoremediation, potassium deficiency, phyto-hormones, bio-energy-activators
ICCBES-1193

Characterization of Air Pollutants Emissions from Motorcycle under ECE and WMTC Driving Modes by Using Ethanol-Blended Gasoline

Jiun-Horng Tsai a,*, Yung-Chen Yao b, I-Ting Wang a, Hsuan-Chi Huang a

a Department of Environmental Engineering & Research Center For Climate Change And Environment Quality, National Cheng Kung University

b Green Energy and Environment Research Laboratories, Industrial Technology, Industrial Technology Research Institute, Hsinchu, Taiwan, R.O.C.

E-mail address: jhtsai@mail.ncku.edu.tw

Abstract

This study investigated the influence on motorcycle emissions by using ethanol-blended gasoline under two driving modes. Ethanol-blend gasoline and commercial unleaded gasoline were applied in two motorcycles with four-stroke fuel-injection engine displacement of 125 cm³ but without catalyst. Emissions were tested on a dynamometer by following ECE and WMTC modes. Emissions of criteria air pollutants (CO, HC, NOx) were analyzed by monitors and organic compounds (VOCs and carbonyls) were sampled and analyzed in the laboratory. The profiles of organic compounds and ozone-forming potential were also evaluated. The results indicate the emissions of criteria air pollutant from ECE and WMTC cycles are similar, but total VOC emissions from ECE mode is 3 time-fold higher than those from WMTC mode. Motorcycle using ethanol-blended gasoline shows lower emission and lower ozone-formation potential under both ECE and WMTC cycles. The results indicated that the emission variations caused by different driving patterns are significantly.

Keyword(s): motorcycle driving pattern, ethanol-blended gasoline, organic air pollutants, ozone-formation potential

1. Introduction

Emissions from vehicle correlates with many parameters, such as fuel property, engine type, driving mode, and exhaust catalyst. Application of ethanol-blended gasoline on vehicles has received attention in many countries due to fuel economy and emissions. A mixture of 90% gasoline and 10% ethanol is referred to E10 which is the most popular blend due to its interchangeability with gasoline and without any special arrangement of fuel/air system on vehicle [1]. Ethanol blended gasoline has been also introduced into many Asian counties, such as Taiwan (ROC), China (PRC), India, Philippines, and Thailand [2, 3]

Small engine motorcycles (50-125 cm³ displacement) are popular in Asian urban areas,
including China, India, Taiwan, Thailand, and Vietnam, which accounts for 50 - 70% of vehicle population. Air quality issue caused by emissions from motorcycle in urban area is also critical in these Asian cities. For example, motorcycles emissions contributed 30% of CO and 70% of THC among all gasoline powered vehicles in Bangkok [4], and accounted for 28% of CO, 52% of THC, and 19% of NOx in Taiwan [5].

Many studies evaluated the effect of ethanol-gasoline blends on passenger car emissions, but only rare studies on emission from small engine motorcycles. Previous studies indicated that passenger cars using ethanol-blended gasoline could reduce CO and THC levels than unleaded gasoline [6-8]. Ethanol-blended gasoline also decreased emissions of air toxics, such as benzene, 1,3-butadiene, toluene, and xylene, but significantly increased emission of acetaldehyde [9, 10].

A representative driving pattern is the convenient mean to test and estimate emission of vehicles on road which provides the variation in vehicle speed over time for a certain period of travel. A driving pattern can represent a typical driving pattern for the vehicle population of a city and is assumed to be repeated continuously, it is a so-called “Driving Cycle” [11]. The Economic Commission for Europe Cycle (ECE) and Worldwide Motorcycle Test Cycle (WMTC) are the current one and the new adopt legislative procedures for motorcycle emission test in Taiwan, respectively.

This study was undertaken to investigate the characteristics of motorcycle engine exhaust by using ethanol-gasoline blend under different driving modes. Emissions of criteria air pollutants, VOCs, and ozone-forming potential are evaluated.

2. Methods

2.1 Test fuels, motorcycles, and procedures

Two test fuels were used in this study. Ethanol-gasoline blend, containing 30% ethanol by volume (E30), and commercial unleaded gasoline (as reference fuel, RF) were applied in the test motorcycles. Two test fuels were prepared by the largest petroleum refinery (China Petroleum Corporation, CPC) in Taiwan. The oxygenated additive of E30 and unleaded gasoline (RF) was ethanol and methyl tert-butyl ether (MTBE), respectively, and the corresponding fuel oxygen contents were 10.1 wt% (E30) and 2.0 wt% (RF).

Table 1 presents the compositions of two test fuels.

Two four-stroke fuel-injection motorcycles were used in the experiments. All test motorcycles were new (zero mileage), four-stroke, single cylinder, and with 125 cm$^3$ displacement. In order to accentuate the effects of the ethanol-gasoline blend, the motorcycles were without any engine adjustment and used a non-catalyst model tailpipe during testing. All test motorcycles
were in good mechanical condition to ensure that their engine combustion chamber deposits had stabilized.

Two test motorcycles were tested on a chassis dynamometer by following the ECE and WMTC cycles in the certified laboratory. The chassis dynamometer system was comprised of a dynamometer, a dilution pipe, a constant volume sampler (CSV) unit (HORIBA, CVS-51S), and an exhaust gas analyzer (HORIBA, MEXA-8320). A specific fuel change protocol was followed to ensure consistency between tests and to ensure minimal crossover between test fuels [12]. Exhaust emission of criteria and organic air pollutants was measured in two motorcycles. Figure 1 shows the sampling schematic diagram. A total of eight tests of various test fuels and driving cycles were conducted to detect exhaust of criteria air pollutants and organic compounds.

2.2 Sampling and analytical of exhaust
For criteria air pollutants, the tailpipes of each motorcycle were connected directly to the CVS system and conducted to a sampling bag with dilution air for the entire test cycle. Criteria pollutant emissions were measured by a non-dispersive infrared analyzer, a flame ionization detection analyzer, and a chemiluminescence detection analyzer, for CO, THC, and NOx (NO and NO₂), respectively. A vacuum box containing a 10 L Tedlar bag was connected directly to the tailpipe to collect organic air pollutant over the entire cycle. Volatile organic compounds (VOCs) were quantified by a gas chromatography/mass spectrometer. Carbonyl components in the exhaust were collected by a cartridges filled with 2,4-DNPH. The cartridge was extracted with acetonitrile in the laboratory before analysis and then the extracted solution was analyzed by a high performance liquid chromatography with an ultraviolet-visible as detector.

The background pollutant concentrations of dilution air were also analyzed routinely and deducted from the test results. A total 54 organic pollutants, included alkanes, alkenes, aromatics, and carbonyls, were analyzed. The R-square of the calibration curves of the 49 VOC species and 15 carbonyl compounds were generally higher than 0.995, the relative standard deviation was less than 10%.
Table 1: Properties of test fuels<sup>1</sup>

<table>
<thead>
<tr>
<th>Fuel property&lt;sup&gt;1&lt;/sup&gt;</th>
<th>RF&lt;sup&gt;1&lt;/sup&gt;</th>
<th>E30&lt;sup&gt;1&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Octane Number&lt;sup&gt;2&lt;/sup&gt;</td>
<td>95.0&lt;sup&gt;3&lt;/sup&gt;</td>
<td>94.9&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethanol (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>—&lt;sup&gt;4&lt;/sup&gt;</td>
<td>26.3&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Oxygen content (wt%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>2.0 (MTBE)&lt;sup&gt;3&lt;/sup&gt;</td>
<td>10.1 (Ethanol)&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Aromatics (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>31.2&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5.1&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Paraffins (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>10.6&lt;sup&gt;3&lt;/sup&gt;</td>
<td>9.2&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Isoparaffins (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>30.6&lt;sup&gt;3&lt;/sup&gt;</td>
<td>43.1&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Olefins (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>10.1&lt;sup&gt;3&lt;/sup&gt;</td>
<td>8.7&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Naphthenes (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>7.0&lt;sup&gt;3&lt;/sup&gt;</td>
<td>6.9&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Benzene (vol%)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.6&lt;sup&gt;3&lt;/sup&gt;</td>
<td>0.1&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Gross heating value (J/g)&lt;sup&gt;2&lt;/sup&gt;</td>
<td>44250&lt;sup&gt;3&lt;/sup&gt;</td>
<td>41510&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>1</sup>RF is a commercial unleaded gasoline; E30 has 30% v/v ethanol in the gasoline.<sup>1</sup>

---

Fig. 1: The schematic diagram of engine exhaust test on a dynamometer<sup>5</sup>
3. Results

3.1 Emissions of criteria air pollutants

Table 2 shows the criteria air pollutant emission factors of two test motorcycles as using G95 and E30 at two driving pattern. Experimental data indicate that CO and THC emissions in engine exhaust were lower than those from reference fuel while using E30 as fuel regardless on ECE or WMTC driving patterns. The reduction is 22/37% (CO) and 29/28% (THC) for ECE and WMTC, respectively. NOx emission also showed a 9% (ECE) and 3% (WMTC) reduction while E30 used in the test motorcycle.

<table>
<thead>
<tr>
<th>Driving Pattern</th>
<th>ECE</th>
<th>WMTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test fuel</td>
<td>CO</td>
<td>THC</td>
</tr>
<tr>
<td></td>
<td>RF</td>
<td>E30</td>
</tr>
<tr>
<td>CO (g/km)</td>
<td>2.00</td>
<td>2.19</td>
</tr>
<tr>
<td>THC (g/km)</td>
<td>0.57</td>
<td>0.40</td>
</tr>
<tr>
<td>NOx (g/km)</td>
<td>0.32</td>
<td>0.29</td>
</tr>
</tbody>
</table>

3.2 Emissions of organic air pollutants

The total VOCs emissions of ECE cycle are 328 mg/km (RF) and 143 mg/km (E30), as well as are 116 mg/km (RF) and 52 mg/km (E30) of WMTC. The emission decreased with increasing ethanol content in fuels regardless ECE or WMTC cycles. For both driving patterns, test motorcycle showed 56.5% (ECE) and 55.8% (WMTC) emission reduction on total VOCs emissions while using E30 as fuel as compared to those from RF.

Table 3 shows the organic air pollutant emission factors for each test fuel for the two driving patterns, respectively. Emission factors of alkanes, alkenes, and aromatics groups of E30 were lower than those of RF either for ECE or WMTC. The reduction values (Figure 2), calculated based on emission factor per driving distance of reference fuel, were 56/57% (alkanes), 67/71% (alkenes), and 65/62% (aromatics) for the ECE and WMTC, respectively. In contrast, emissions of carbonyls show large increase. It increasing about 51% for ECE test cycle and 53% for WMTC cycle, compared to the reference fuel.

Compounds of alkanes, alkenes, aromatics, and carbonyls groups decreased while testing at WMTC cycle as compared to those in ECE under the same test fuel. The reduction ranged from 57 to 69% (RF) and 57 to 73% (E30) of each VOC group (Figure 3). More emission reduction of each VOC groups was observed in the different test cycle than those of same test fuel.
3.3 Ozone-formation potential

Figure 4 shows the ozone formation potential (OFP, in g-\(\text{O}_3\) produced per km) of motorcycle exhaust fueled with RF and E30 for both ECE and WMTC test cycles. Results indicated the
sequence of OFP was ECE-RF > ECE-E30 > WMTC-RF > WMTC-E30. The OPF is 0.19 g-O₃/km for the test of WMTC fueled with E30, and is 1.36 g-O₃/km for the test of ECE fueled with RF. Ozone-formation potential of the total VOCs emission in the engine exhaust reduced near 57% while using E30 as fuel under the same test cycle as compared to RF, and the reduction of OFP is 85% in WMTC+E30 test as compared to those of ECE with RF.

The aromatic groups caused higher ozone formation potential for all test motorcycles. The aromatic groups contributed 35-51% of the ozone. However, the contribution of carbonyl group is dramatic raised when E30 blend used in the test motorcycles for both ECE and WMTC test cycles. It contributed 20% and 26% as fueled with E30 blend for ECE and WMTC, respectively, and the values are 4% and 5% while using RF as fuel. Acetaldehyde had the highest ozone formation potential among 15 carbonyl compounds for all tests. It contributed 67% (ECE) and 60% (WMTC) when E30 blend used in the test motorcycles.

![Ozone formation potential (g-O₃/km) of engine exhausts by unleaded gasoline (RF) and ethanol-gasoline blend (E30) at two driving patterns](image)

### 3.4 Acknowledgments

The authors would like to acknowledge the National Science Council of the Republic of China (Taiwan) for the financial support through NSC grant no. NSC 98-2221-E-006-006-MY3 and NSC 101-2221-E-006-160-MY3

### 4. References


Information Engineering (2)

Wednesday, May 11, 2016  08:45-10:15  Room 1007

Session Chair: Prof. Kyungkoo Jun

ICEAI-957
Vehicle Sound Classification Using Principal Component Analysis and a Neural Network
Jian-Da Wu | National Changhua University of Education
Guan-Jhang Hong | National Changhua University of Education
Yu-Yu Chen | National Changhua University of Education

ICEAI-1009
Seismic Properties and Pattern Recognition of Monthly Number of Earthquakes in the Eastern Coast Counties of Taiwan
Ko-Ming Ni | Ling Tung University

ICEAI-1061
A Real-Time Video Restoration Method for Motion-Blurred Frames Based on Motion Vector
Chao-Ho Chen | National Kaohsiung University of Applied Sciences
Tsong-Yi Chen | National Kaohsiung University of Applied Sciences
Wu-Chih Hu | National Penghu University of Science and Technology
Ji-Yi Yang | National Kaohsiung University of Applied Sciences

ICEAI-1074
A Novel Seam Finding Method Using Downscaling and Cost for Image Stitching
Jinwook Jeong | Incheon National University
Kyungkoo Jun | Incheon National University
ICEAI-1080
A Heuristic for Maximizing the Lifetime of Data Aggregation in Wireless Sensor Networks
Bing-Hong Liu | National Kaohsiung University of Applied Sciences
Van-Trung Pham | Pham Van Dong University
Ngoc-Tu Nguyen | National Kaohsiung University of Applied Sciences
Yi-Sheng Luo | National Kaohsiung University of Applied Sciences

ICEAI-1087
Student Authentication Method by Update of Face Information in e-Learning System
Taisuke Kawamata | Tokyo University of Science
Susumu Fujimori | Tokyo University of Science
Takako Akakura | Tokyo University of Science
ICEAI-957

Vehicle Sound Classification Using Principal Component Analysis and a Neural Network

Jian-Da Wu*, Guan-Long Hong, Yu-Yu Chen
Graduate Institute of Vehicle Technology, National Changhua University of Education, 1 Jin-De Rd., Changhua City, Changhua 500, Taiwan, ROC
jdwu@cc.ncue.edu.tw

Abstract

This study develops a classification system for vehicle type using sound signals and neural network techniques, under various engine operation conditions. This architecture is divided into two parts. Firstly, the sound signals for different vehicles are collected with the engine running and then a match database is established. Principal component analysis (PCA), which is a method of feature extraction that reduces the computational load, is used. Secondly, feature vectors are extracted, using PCA, and these data are used as the neural network input. An artificial neural network, which includes a radial basis function neural network (RBFNN) and a generalized regression neural network (GRNN), is used to train these features and to classify the signals. Finally, the training time and the recognition rate for the proposed system are compared. The experimental results show that this vehicle type identification system uses less feature vectors to do any training and achieves good recognition results in the experimental case.

Keywords: principal component analysis (PCA), radial basis function neural network (RBFNN), generalized regression neural network (GRNN), vehicle type identification, sound signal

1. Introduction

Because of the rapid development of the vehicle industry, it has become the most widespread form of transportation. When vehicle technology changes rapidly, new equipment becomes more diversified. The focus is now on active security using intelligent equipment and suitability to different lifestyles. The purpose of this study is to establish a vehicle type identification system, which is not installed directly in the vehicle, but which provides information to the vehicle’s intelligent systems. It has a very broad by range of applications, such as vehicle monitoring and identification, the identification of vehicles at highway toll stations, or in anti-theft systems. There are many ways to achieve system identification. The most common methods use sound, vibration, video and image technology, depending on practicality, convenience, feasibility, and other considerations.
Many studies have been published on vehicle type identification techniques [1-4]. In the relevant literature on vehicle type identification, the research uses image processing or photo capture techniques for system identification. In 2009, Wang used original vehicle images for feature extraction and then used a RBFNN as the classifier, to identify vehicles [1]; In the same year, Zhang et al. used an auxiliary CCD camera to take vehicle images and to do pre-processing and then used Fuzzy C-Means clustering (FCM) to extract the data features. Finally a BPNN and a RBFNN were used for classification; the results were good [2]. In 2010, Daya et al. used vehicle pictures for the identification of license plates and vehicle types and achieved good recognition results [3]. Several studies have used image or video extraction techniques for vehicle identification. However, because of the greater amount of pixel data, more space is required in the data memory, so computation becomes lengthy.

In this study, sound signals are used, because sound signal processing is easier than image processing and there is less data. Therefore, the sound signals with the engine running are measured and then pre-processed for feature extraction. The features are used to identify different vehicle types. Because there are many types of vehicle, the use of the sound signal to identify vehicles requires the establishment of a complete database. In addition, light has an effect on the recognition results.

2. The Principles of Principal Component Analysis
This experiment collects the sound signals with the engine running and extracts the features to use as a neural network input. The collected sound signals are time-domain signals. The signal in the time-domain gives a complete relationship between time and energy, during the collection process, but large differences or features are not recognized, so the signal pre-processing is performed first and the time-voltage signal undergoes a fast Fourier transform (FFT), so the signal from the time-domain is converted into the frequency-domain and principal component analysis (PCA) can be used to extract its main features and to obtain the necessary information. PCA was proposed by Karl Pearson, in 1901 [5]. It is a multi-variable analysis method that is used to simplify data sets. PCA is often used to reduce the dimensions of data sets and it retains the original data sets in a covariance matrix to find the largest features. The covariance matrix is used for feature decomposition [6] and to obtain the eigenvectors and eigenvalues.

In the process of reducing the dimensions, PCA uses the original data sets in a linear combination and produces new data for a new variable, which is less than the original data sets, This new variable is called the main component. As shown in Fig. 1.
Using PCA to do data analysis involves several steps. Firstly, the sample data must be collected. If the number of features of each signal collected is \( n \), it forms the original sample data \( X = \{x_1, x_2, ..., x_n\} \), calculated using Eq. (1), with the original sample data of the covariance matrix, \( C_x \), where \( \bar{x} \) is the average vector of \( X \).

\[
C_x = \frac{1}{n-1} \sum (x_i - \bar{x})(x_i - \bar{x})^T \tag{1}
\]

The covariance matrix of eigenvalues and eigenvectors are calculated using (2). From large to small order:

\[
\lambda_1, \lambda_2, ..., \lambda_s
\]

The corresponding eigenvectors are calculated using (3):

\[
E_1, E_2, ..., E_s \tag{2}
\]

Using the largest eigenvalues and the corresponding eigenvectors, Eq. (4) is used to obtain the \( j \)-th of principal component:

\[
y_j = E_j^T X \quad j = 1, 2, 3, ..., n \tag{3}
\]

The number of main component depends on the contribution of main component, \( q \), as follows. Eq. (5) is used to obtain \( q \):

\[
q = \frac{\lambda_1 + \lambda_2 + ... + \lambda_s}{\lambda_1 + \lambda_2 + ... + \lambda_s} \tag{4}
\]

where \( n > m \).

Therefore, each feature vector, \( \xi \), is the main component. The first principal component comprises the largest eigenvalues, \( \lambda_1 \), of the feature vector, \( \xi \), and the second main component comprises the consecutively larger eigenvalues, \( \lambda_2 \), of feature vector, \( \xi \), and so on.

PCA converts the feature parameters of the original signal to obtain a new set of feature parameters \( y_1, y_2, ..., y_s \). This group of feature parameters has reduced dimensions, which allows the use of less dimensions for the features of each vehicle and reduces the input for the neural network.
3. The Principle of Neural Network Classifiers

3.1 Radial Basis Function Neural Network

Radial basis function neural networks (RBFNN) and back-propagation neural networks (BPNN) are similar. In 1985, Powell proposed a multi-variable interpolation of a radial basis function (RBF) method [7] and in 1989, Moody et al. proposed a neural network structure that had RBF neural networks [8]. RBFNN is a supervised learning network, which has a simple structure, allows good approximation, has a fast convergence speed and is stable.

Fig. 2 shows the architecture of a RBFNN. It is a three layer feed-forward network, which includes an input layer, a hidden layer and an output layer. RBFNN sets a radial basis function in the hidden layer and uses an approximation method to find the mapping relationship between the input and the output of the network. It sends the training sample data to the network, after the input layer of input vectors are assigned to each neuron of the radial basis function in the hidden layer, and calculates the input vector data for each hidden layer neuron center of Euclidean distance, using the converted RBF and the hidden layer output. The hidden layer to the output layer space belongs to the linear space mapping. That is, the output layer function is a linear model, which increases the network’s learning speed. Finally, the result of the hidden layer output is weighted and then transmitted to the output layer and a linear model is used for classification and recognition.

![Fig. 2 Architecture diagram of RBFNN](image)

The action Function in the hidden layer often uses a non-linear Gaussian function, as in Eq. (6):
3.2 Generalized Regression Neural Network

A generalized regression neural network (GRNN) is a type of supervised learning network, which is a form of radial basis network. It has a strong nonlinear mapping ability, so it can approximate any type of function and the training speed is fast. GRNN uses an evolution of a probability neural network (PNN). In 1991, Specht proposed a learning algorithm [9]. Because GRNN is inspired by the probability model, it need not assume a determination function form. It presents a probability density function.

Fig. 3 shows the architecture of a GRNN. There are four layers: the input layer, the pattern layer, the summation layer and the output layer. The input layer sends the feature vectors into the network. The pattern layer uses each neuron function to calculate the relationship between the input feature vectors and the training samples. It does not need to set up the number of neurons, as this depends on the input data. The summation layer accumulates the pattern layer output and sends it to the output layer for classification and to determine the probability.

\[ v_j = z(v_j) = \exp \left( - \frac{v_j^2}{2\sigma_j^2} \right) \]  

\( \sigma_j \) is the width of neurons and \( v_j \) is used to calculate the Euclidean Distance between the input vectors and neurons. As defined in Eq. (7).

\[ d_j(x) = \| x - c_j \| = \sqrt{\sum_{i=1}^{m} (x_i - c_{ji})^2} \]  

When \( x = [x_1, x_2, \ldots, x_m] \) is the \( i \)th input signal, where \( i = 1, 2, \ldots, m \). \( c_{ji} \) is the \( j \)th vector of the RBF centers in the hidden layer; \( j = 1, 2, \ldots, m \). The output shape of the network linearly weights the number of basis function in the hidden layer and the sum is obtained. The output value is determined using Eq. (8):

\[ y_k = \sum_{j=1}^{m} d_j z_j \]  

The hidden layer, which composes \( j \)-th hidden nodes, from the input layer to the hidden layer space, is a nonlinear conversion. \( d_j \) is the \( j \)th center point of hidden layer and corresponds to the \( k \)th output weight values of the output layer. \( z_j \) represents the \( j \)th hidden layer neuron and its RBF output values, \( j = 1, 2, \ldots, m \).

\[ y_k = \sum_{j=1}^{m} d_j z_j \]
Firstly, $f(x, y)$ is assumed to be the random variables, $x$ and $y$, of a probability density function (PDF). $X$ is a measure value for the random variables, $x$ and $y$, on the $X$ of the regression, using the following Eq. (9):

$$E[y \mid X] = \frac{\int_{-\infty}^{\infty} y f(X, y) \, dy}{\int_{-\infty}^{\infty} f(X, y) \, dy} \quad (9)^{\text{4}}$$

When $f(x, y)$ is unknown, it is usually estimated from observed values of $x$ and $y$. Parzen's proposed Parzen window method [10] is used to estimate $f(x, y)$. The probability estimate $\hat{f}(x, y)$ is based on the random variables, $x$ and $y$, of sample values $X^i$ and $Y^i$, where $n$ is the sample number of observations and $p$ is the dimension of vector $x$. Using Eq. (10):

$$\hat{f}(x, y) = \frac{1}{(2\pi)^{p/2} \sigma^p} \frac{1}{n} \sum_{i=1}^{n} \exp \left[ -\frac{(X - X^i)^T (X - X^i)}{2\sigma^2} \right] \exp \left[ -\frac{(Y - Y^i)^2}{2\sigma^2} \right] \quad (10)^{\text{4}}$$

The physical interpretation of the probability estimation $\hat{f}(x, y)$ assigns $\sigma$ width of sample estimates to each sample, $X^i$ and $Y^i$, so the probability estimate is the sum of the sample probabilities. Its scalar function is defined as Eq. (11):

$$D^i = (X - X^i)^T (X - X^i) \quad (11)^{\text{4}}$$

Substituting Eq. (11) into the Eq. (10), produces Eq. (12):

$$\hat{y}(X) = \frac{\sum_{i=1}^{n} Y^i \exp \left[ -\frac{D^i}{2\sigma^2} \right]}{\sum_{i=1}^{n} \exp \left[ -\frac{D^i}{2\sigma^2} \right]} \quad (12)^{\text{4}}$$

$\sigma$ is the smoothing parameter. It is a constant greater than zero.
4. Experimental Conditions and a Discussion of the Results

4.1 Experimental Equipment

In this experiment, in order to discriminate between types of vehicle, ten vehicles were used as samples. Five gasoline vehicles and five diesel vehicles of different were used. Each vehicle had its engine run at idle speed, 750rpm, 1500rpm, 2200rpm and 3000rpm for four different operation conditions. The sound signal for each engine speed was collected 30 times, for a total of 1200 items. When the engine was running, a microphone was used to measure the sound signal. The microphone was placed 0.3m in front of the engine and a data acquisition system (NI-6024E) and a data acquisition card (NI-9233) were used to collect the sound signals, with Labview software. The sampling frequency was 25 kHz and the sampling time was 10 seconds. The analog signal was converted to a digital signal and stored. Finally, these original data were pre-processed, features were extracted and the result was classified using a PC, to give a recognition result. Fig. 4 shows the experimental process. Table 1 lists the vehicle brands and types used for the experiment. A to E are gasoline vehicles, and F to J are diesel vehicles. Fig. 5 shows the procedure for vehicle classification.
4.2 Data Pre-Processing and Feature Extraction

The collected data were time-domain signals, and these were converted to frequency-domain signals, using a FFT, to determine the different features for each vehicle.

In the experiment, due to the large amount of data and in order to effectively extract the features of each signal, PCA was used to process the data and to reduce the size of the dataset, to reduce the dimensions for complex data and to calculate the correlations between the data. The maximum variance of the main components was retained and the eigenvalues and corresponding eigenvectors were determined. PCA uses less feature points to represent a signal, because it extracts the main component values as its main features. Figs. 6 summarize the
results for ten feature vectors, extracted using PCA, as the main features for each vehicle for engine speed signals. In the figure, the distribution for vehicle and engine speed for the main component of the feature vectors is obviously seen. This feature vectors were used as the input vector for the neural network classification, which reduces the number of features and the computing time to achieve better recognition. The horizontal axis represents the number of features and the vertical axis represents the size of the feature values. The figures on the left, A to E, are for the five gasoline vehicles, and those to the right, F to J, are for the five diesel vehicles, in order from top to bottom.

4.3 System Discrimination
The discrimination in this system has three types. As shown in Table 2, case 1 discriminates vehicle classes, into gasoline or diesel vehicles; case 2 discriminates different engine speeds, that is, the four different running speeds idle, 750rpm, 1500rpm, 2200rpm and 3000rpm, and case 3 discriminates different vehicle types, A to J. A to E are gasoline vehicles and F to J are diesel vehicles, giving a total of ten different types of vehicle.

4.4 Training and Testing of the Neural Network
A RBFNN and GRNN were used to train and test the classifier. This system establishes of network for external training and test. So-called external training is not repeatable for the training data and the test data. Table 3 shows the difference in the discrimination cases, in terms of the number of data for training and testing. The total number of data items is 1200. Case 1 discriminates vehicle classes: gasoline and diesel vehicles, each of which constitutes 600 items. The first 300 items are used for training and the last 300 items for testing. Case 2 discriminates the four engine speeds, each of which constitutes 300 items. The first 150 items are used for training and the last 150 items for testing. Case 3 is discriminates vehicle type and the ten different vehicles each have 120 items. The first 60 are used for training and the last 60
4.5 Results and Discussion

This study uses PCA for feature extraction for each vehicle with the engine running by collecting the sound signals, and then uses a RBFNN and a GRNN to train the network for the whole system and for classification, to identify each vehicle type. Table 4 shows the system for vehicle class classification, gasoline or diesel, and compares the recognition rate. It is seen that the recognition rate for gasoline vehicles is higher than that for diesel vehicles. The recognition rate for gasoline vehicles is more than 90%, while that for diesel vehicles is more than 80%, using a RBFNN and a GRNN. However, in the identification of gasoline and diesel vehicles, the average recognition rate is more than 90% and the GRNN performs better than the RBFNN.

Table 5 shows the system for different speed classification, for the four engine speeds: idle, 750rpm, 1500rpm, 2200rpm and 3000rpm by comparing the recognition rate. From the Table 5, it is seen that identification at idle, 750rpm, has the fastest recognition rate of the four conditions. The recognition rate is 97% and 99%, respectively, for the RBFNN and GRNN. At 3000rpm, the recognition rate for the GRNN is 94% and remaining speeds have recognition rates of only 60% to 70%. On the whole, in the identification of different engine speeds, the average recognition rate is more than 70% for a RBFNN and more than 80% for a GRNN.
Table 6 shows the system for vehicle type classification. Ten vehicles, A to J, are identified and the recognition rate compared. A to E are gasoline vehicles and F to J are diesel vehicles. The vehicle types are shown in Table 1. From Table 6, it is seen that vehicles C and G vehicles have a greater than 90% of recognition rate and vehicle H has a rate greater than 80%, using RBFNN. Using GRNN, vehicle C has a 100% recognition rate, F, G, H and J have a rate of more than 95% and vehicle D has a rate of more than 80%. Vehicles B and E vehicles have low of recognition rates of only 50% to 60%.

There are two possible reasons for this. Firstly, in normal conditions, these two vehicles provide similar data for the 30 sound signals in each of the conditions, but probably because of different vehicle condition, such as the booming noise from some mechanical elements, and because there are a few different signals whose features are extracted later, these features, which are used for external training, are different, so the recognition is less than ideal. Secondly, because the sound signals are collected with the engine running, the mechanical operation is cyclical and the same speed for different types produces a main peak in the FFT-derived spectrum at the same frequency. The only difference is in the energy values, so the features are similar. However, because of the different types and condition of vehicles, other energy peaks or noise are produced, so there is a smaller possibility of poor recognition rate but it is not impossible. On the whole, in the identification of different vehicle types, the average recognition rate is more than 70% for the RBFNN and more than 80% for the GRNN. Using a RBFNN and GRNN for system recognition for three different cases of classifiers, where the network training time does not exceed one second and less for the GRNN, so the GRNN trains
Tables 4 to 6 show that this system recognizes three different cases. In terms of the recognition rate or the network training time, the performance using a GRNN is better than that for a RBFNN. A GRNN is a type of RBFNN, but the RBFNN input layer in the hidden layer is nonlinear, so each neuron uses the action function in the hidden layer, so the GRNN can approximate any type of function and has a stronger nonlinear mapping ability, so the learning speed is faster than that of the RBFNN. The recognition results and the network training time are better than those for the RBFNN.

5. Conclusions

This study proposes a vehicle type identification system using the sound signal of an engine running. The identification process uses principal component analysis for feature extraction and the PCA effectively extracts the main component. A radial basis function neural network and generalized regression neural network is used as the classification method, and the results are compared. The experimental results show that the recognition results and the network training time using a GRNN are better than those for a RBFNN. This system can identify vehicle types effectively.

6. References


ICEAI-1009
Seismic Properties and Pattern Recognition of Monthly Number of Earthquakes in the Eastern Coast Counties of Taiwan

Ko-Ming Ni
Department of Information Management, Ling Tung University, Taiwan
lukenee@mail.ltu.edu.tw

Abstract
Two purposes are set for this paper. The first one is to find out the statistic properties of 2,986 labeled earthquakes data recorded in the seismic archive of the Central Weather Bureau (CWB) of Taiwan from January 1995 to December 2015. The second is to scrutinize those data in three counties in the eastern coast of Taiwan - Yilan, Hualien, and Taitung, to find patterns of monthly earthquake numbers, and use them to forecast monthly numbers of these areas in the near future. Totally 2,111 out of 2,986 earthquakes, that is 70.7%, occurred in these three counties.

Hualien, a county in the east of Taiwan, has the most frequent number of earthquakes with 1,211 out of 2,986 times (40.6%) occurring there. Roughly speaking, people there can experience one tremor of ground in a week. Most of earthquakes in Taiwan’s twenty municipal cities and counties are categorized to be shallow (<70km), except that Keelung with average focus of 87.3 km, is intermediate-depth. Maybe it is because earthquakes in Keelung are in the submerged tectonic plate. In the past 21 years (1995 to 2015) the strongest magnitude (Richter scale, Mₗ) is 7.3, which occurred on September 21, 1999 in Nantou County and took away 2,415 lives as well as injured 11,305 people (wiki/921_earthquake).

The author uses one of the most versatile algorithms, ARIMA(p,q,r) model, as a tool to find out seismic patterns in Yilan, Hualien, and Taitung Counties, and finds that ARIMA(3,0,0) model can obtain the most accurate results for Yilan County; ARIMA(1,0,1) model is very suitable for Hualien County; and ARIMA(1,0,0) is the best one for Taitung County. The mean absolute percentage errors (MAPE) obtained by the forecasting of the aforementioned ARIMA(p,q,r) models for Yilan, Hualien, and Taitung for the past five years (60 months, from January 2011 to December 2015) are 49.50%, 88.93%, and 48.62%, respectively. Although there is still much room for improvement, the proposed method may give a dim light in a long dark tunnel for the earthquake forecasting.

Keywords: CWB Archive, ARIMA Model, Seismic Pattern, MAPE

1. Introduction
Earthquake forecasting has long been an area that scientists are eager to explore, but up to now there seem no reliable methods available. Can earthquakes be forecasted accurately? If can, where, when, and what magnitude will it be? These questions have bothered scientists for a long time, and are worthy of study.

The author tries to use earthquake records in Taiwan, together with time series models to find out a seismic pattern, and use it to forecast the number of earthquakes that might happen in each month for the near future.

Twenty (20) municipal cities and counties of Taiwan, Republic of China (R.O.C.), are used in this study. They are, Yilan, Hualien, Taitung, Nantou, Keelung, Taipei, New Taipei, Taoyuan, Hsinchu, Miaoli, Taichung, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung, three islets Penghu, Kinmen, and Matsu (corresponding locations can be referred to in Appendix 2). Such an arrangement is based on the geographical locations from east, central, and to the west of Taiwan.

Earthquake data are obtained from the Central Weather Bureau (CWB) public archive (CWB, 2016), and each earthquake belonging to which area is based on the name given by the CWB. There are labeled (given earthquake number) and unlabeled records of earthquakes (small scale) on the report of CWB. In this study, only labeled earthquakes (with numbers) are used, and unlabeled ones (with records, but no number) are discarded because their influence may be just localized or insignificant. The earthquake label always starts from number one at the beginning of each year, and the name of each earthquake is based on the closest seismometer location to the epicenter.

2. Properties of Earthquakes of Each City/County of Taiwan

Totally 2,986 earthquakes are recorded by the Central Weather Bureau from January 1995 to December 2015 (21 years). After tedious data manipulation and arrangement, the number of earthquakes in each city and county are summarized in the following table:
Table 1: Earthquake data for each city and county in Taiwan (From January 1995 to December 2015):

<table>
<thead>
<tr>
<th>City/County</th>
<th>Numbers of earthquakes</th>
<th>Mean times per month</th>
<th>Mean times per year</th>
<th>Earthquake percentage (%)</th>
<th>Depth (km)</th>
<th>Magnitude (Richter Ms)</th>
<th>Total Energy Released (ergs)</th>
<th>Average Time (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yilan</td>
<td>509</td>
<td>2.0</td>
<td>24.2</td>
<td>17.05</td>
<td>36.7</td>
<td>4.42</td>
<td>6.33E+22</td>
<td>15.0</td>
</tr>
<tr>
<td>Hualien</td>
<td>1,211</td>
<td>4.8</td>
<td>57.7</td>
<td>40.56</td>
<td>16.7</td>
<td>4.21</td>
<td>1.10E+23</td>
<td>6.4</td>
</tr>
<tr>
<td>Taitung</td>
<td>391</td>
<td>1.6</td>
<td>18.6</td>
<td>13.09</td>
<td>19.8</td>
<td>4.56</td>
<td>6.32E+22</td>
<td>19.5</td>
</tr>
</tbody>
</table>
In the above table, the energy of earthquakes released is based on the equation, \( \log_{10}E = 11.8 + 1.5M_S \), given by Gutenberg and Richter (Kramer, 1996). Many variations of \( M_S \) (shear-wave magnitude) formulas take into account the effects of specific geographic regions, so that the final computed magnitude is reasonably consistent with Richter's original definition of \( M_L \) (Pidwirny, 2011). In this study, the author does not distinguish these two magnitudes. During energy calculation, \( M_S \) was substituted by \( M_L \).
2.1 Number of Earthquakes in Each City and County

This subsection is used to find the earthquake frequencies of each city and county in Taiwan for the past 21 years from January 1995 to December 2015. Both bar and PI charts are used to identify number and percentage (%) of earthquakes in each locality.

Figure 1: Total number of earthquakes from January 1995 to December 2015 for each city/county in Taiwan.

Figure 2: Percentage (%) of frequency of earthquakes of each city/county to Taiwan’s total number of earthquakes from January 1995 to December 2015.
From the above figures, one finds Hualien is the most active place for earthquakes in Taiwan. There are 1,211 out of totally 2,986 earthquakes in Hualien, and the ratio is 40.6%. Yilan takes the second place, with 509 times (17.0%), and Taitung is the third, with 391 times (13.1%).

2.2 Mean Times per Month

![Graph showing mean times per month of earthquakes for each city/county in Taiwan from January 1995 to December 2015.]

No doubt, Hualien is the champion of the mean times per month. In each month there are 4.8 times of labeled earthquakes there. Yilan and Taitung have 2.0 and 1.6 times respectively.

2.3 Mean Times per Year
The most frequent of earthquake occurring per year is in Hualien with the number 57.7, then followed by Yilan (24.2), and Taitung (18.6).

2.4 Mean Depth (km)

Almost all the mean depth of hypocenters of earthquakes in Taiwan are shallow (<70 km), except Keelung (87.3 km), which is classified as intermediate-depth. Maybe it is because earthquakes in Keelung occur on the submerged tectonic plate.
2.5 Mean Magnitude (Richter scale, ML)

Surprisingly, the highest mean magnitude (Richter, ML) for Taiwan is in Keelung (5.4). The mean value of magnitude of all earthquakes from January 1995 to December 2015 is 4.2 (ML). Rarely catastrophic earthquake has occurred in Keelung, although the mean magnitude there is higher than any other places. It is probably focuses of earthquakes are deep in that area so the waves attenuate to the surface are less harmful.

2.6 Maximum Magnitude of Earthquakes for Each City/County in Taiwan
The maximum magnitude of earthquakes in Taiwan for the past 21 years is 7.3 (Richter magnitude scale $M_L$) in Nantou on September 21, 1999. Totally 2,415 people died and 11,305 were injured in that earthquake (wiki/921_earthquake).

### 2.7 Mean Time (dTime in days) between Two Earthquakes in Each City/County

![Average days between two earthquakes (dTime) in each city/county](image)

Mean interval of time between two earthquakes for each city/county is defined as dTime (days). In Hualien, people might experience a tremor of ground every 6.4 days, and for Changhua the interval of two earthquakes takes 769.9 days. Two counties, Kinmen and Matsu are excluded from this analysis because no earthquake record has been found.
2.8 Mean Ratio of Energy (ergs)

The energy calculation for each earthquake is based on the equation given by Gutenberg and Richter (Kramer, 1996). The energy released from all labeled earthquakes is calculated by equation \( \log_{10} E = 11.8 + 1.5M_S \) (ergs). The energy release of total labeled earthquakes of each area to that of total labeled earthquakes in Taiwan from January 1995 to December 2015 is expressed in ratio. Nantou (24.2%) is similar to Hualien (24.7%) although the number of earthquakes of these two areas differ tremendously (191 and 1,211 respectively). The energy is expressed in logarithm scale, the 7.3 magnitude of earthquake on September 21, 1999 in Nantou contributes a significant portion of energy.

3. Pattern Recognition of Monthly Number of Earthquakes in Yilan, Hualien, and Taitung Counties

The three counties with most frequent earthquakes - Yilan, Hualien, and Taitung, are discussed in this paper, and they are all in the eastern coast of Taiwan. There are 2,111 out of totally 2,986 earthquakes occurring in these three counties in the past 21 years, that accounts for 70.7% and hence they are worthy to scrutinize.

The ARIMA(p,q,r) (Autoregressive Integrated Moving Average) model is one of the most powerful algorithms in time series analysis (Hanke & Wichern, 2009). In this section, the author hopes to find a pattern of the number of times of earthquake occurring in a month for each aforementioned county, and uses that pattern to forecast the number of earthquakes in a month in the near future. Note that all the ARIMA(p,q,r) models used in this section satisfy the
test procedures in the flow chart of Appendix 1, including the $\chi^2$ test of the autocorrelation function of residuals of each ARIMA model.

3.1 Earthquakes per Month in Yilan

![Time series of earthquakes in Yilan County](image)

Figure 10: Number of earthquakes per month in Yilan from January 1995 to December 2015.

In Yilan County, the mean earthquake frequency is 2.02 times per month. The I-chart used here is to indicate where the extreme values might be.

3.1.1 Pattern Recognition of Monthly Number of Earthquakes in Nantou

From the autocorrelation function (ACF) (Figure 11) and the partial autocorrelation function (PACF) (Figure 12) diagrams of frequency of earthquakes for each month in Yilan, the author finds they are not random data. If one can find a pattern to simulate the earthquake behavior, then the number of earthquakes per month in Yilan can be forecasted.
Figure 11: Autocorrelation function (ACF) of earthquakes per month in Yilan.
3.2 Earthquakes per Month in Hualien
In Hualien County, the mean earthquake frequency is 4.80 times per month. The I-chart used here is to indicate where the extreme values might be.

Following the same procedures as those in Yilan County, the author finds that ARIMA(1,0,1) is a good model for Hualien County.

**3.3 Earthquakes per Month in Taitung**

In Taitung County, the mean earthquake frequency is 1.55 times per month. The I-chart used here is to indicate where the extreme values might be.
Following the same procedures as those in Yilan County, the author finds that ARIMA(1,0,0) is a good model for Taitung County.

Using the ARIMA(p,q,r) models proposed for Yilan, Hualien, and Taitung, and computing real and the forecasted number error through the mean absolute percentage errors (MAPE) for the past five years (60 months, from January 2011 to December 2015), one obtains the results as in Table 2.

The mean absolute percentage error (MAPE) (Hanke and Wichern, 2009) has the form as in Equation 1.

\[
MAPE = \frac{1}{n} \sum_{t=1}^{n} \left| \frac{Y_t - \hat{Y}_t}{Y_t} \right|
\]

(1)

Where \( Y_t \) = the actual value in time period \( t \), \( \hat{Y}_t \) = the forecasted value for period \( t \), \( n \) = number of months.

### Table 2: Comparison of Forecasting and Real Number of Earthquakes per Month in Yilan, Hualien, and Taitung Counties from January 2011 to December 2015

<table>
<thead>
<tr>
<th>County</th>
<th>ARIMA Model</th>
<th>MAPE Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yilan</td>
<td>ARIMA(3,0,0)</td>
<td>49.50</td>
</tr>
<tr>
<td>Hualien</td>
<td>ARIMA(1,0,1)</td>
<td>88.93</td>
</tr>
<tr>
<td>Taitung</td>
<td>ARIMA(1,0,0)</td>
<td>48.62</td>
</tr>
</tbody>
</table>

Using the ARIMA model recognized for each county, the author forecasts the number of earthquakes per month for Yilan, Hualien and Taitung counties for the next five months as in the following table.

### Table 3: Forecasting Earthquakes per Month for Yilan, Hualien, and Taitung Counties from January to May in Year 2016

<table>
<thead>
<tr>
<th>Year 2016</th>
<th>Yilan [ARIMA(3,0,0)]</th>
<th>Hualien [ARIMA(1,0,1)]</th>
<th>Taitung [ARIMA(1,0,0)]</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>1</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>February</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>March</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>April</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>May</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
</tbody>
</table>

4. Conclusions

After analyzing earthquake data from January 1995 to December 2015, the following conclusions can be obtained:

(1) Hualien is the most active place for earthquakes in Taiwan. There are 1,211 out of totally 2,986 earthquakes in Hualien, and the frequent ratio is 40.6%. Yilan takes the second place, occurring 509 times with the ratio of 17.0%. Taitung is the third, with the ratio of 13.1%.
(2) In each month, 4.8 times of labeled earthquakes happened in Hualien, 2.0 times in Yilan, and 1.6 times in Taitung respectively.

(3) The highest frequency of earthquakes per year is in Hualien with a number of 57.7, and followed by Yilan (24.2), and Taitung (18.6).

(4) Almost all the mean depth of hypocenters of earthquakes in Taiwan are shallow (<70 km), except Keelung (87.3 km), which is classified as intermediate-depth. Maybe it is because earthquakes in Keelung are in the submerged tectonic plate.

(5) The highest mean magnitude (Richter, M_L) for Taiwan is in Keelung (5.4, M_L). The mean value of magnitude of all earthquakes from January 1995 to December 2015 is 4.2 (M_L).

(6) The maximum magnitude of earthquakes in Taiwan for the past 21 years is 7.3 (Richter magnitude scale, M_L) in Nantou on September 21, 1999.

(7) In Hualien, people there might experience a tremor of ground every 6.4 days, and in Changhua the interval between two earthquakes takes 769.9 days, which is the longest in Taiwan.

(8) The ratio of earthquake energy released in Nantou (24.2%) is similar to that in Hualien (24.7%) although the number of earthquakes of these two areas differ tremendously (191 and 1,211 respectively).

(9) By checking the mean absolute percentage errors (MAPE) for the past five years (60 months), the author finds that ARIMA(3,0,0) can be used in forecasting the monthly earthquake numbers in Yilan County with an error of 49.50%; ARIMA(1,0,1) model is very suitable for Hualien County with an error of 88.93%; ARIMA(1,0,0) is the best for Taitung County with an error of 48.62%.

5. References


Appendices

Appendix 1: ARIMA(p,q,r) Forecasting Procedures
Appendix 2: Cities and Counties of Taiwan

There are totally twenty (20) municipal cities and counties in Taiwan- Yilan, Hualien, Taitung, Nantou, Keelung, Taipei City, New Taipei City, Taoyuan, Hsinchu, Miaoli, Taichung, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, Pingtung, Penghu, Kinmen, and Matsu (Lienchiang). Their corresponding locations can be found in the following map (bing.com, 2016).
Figure A2: Map of Taiwan’s cities and counties (bing.com, 2016)
ICEAI-1061
A Real-Time Video Restoration Method for Motion-Blurred Frames Based on Motion Vector

Chao-Ho Chen\textsuperscript{a*}, Tsong-Yi Chen\textsuperscript{a}, Wu-Chih Hu\textsuperscript{b}, Ji-Yi Yang\textsuperscript{a}

\textsuperscript{a}Department of Electronic Engineering, National Kaohsiung University of Applied Sciences, Kaohsiung, Taiwan, R.O.C.
\textsuperscript{b}Department of Computer Science and Information Engineering, National Penghu University of Science and Technology, Taiwan, R.O.C.

thouho@kuas.edu.tw

Abstract
This paper presents a realtime video restoration method for motion-blurred frames captured by a moving video camera. The proposed method mainly consists of point spread function (PSF) estimation, single-image deblurring and multi-image deblurring. Firstly, a frame is divided into many blocks, and then the corner detection technique is used to generate feature points and the optical-flow technique is employed to obtain the motion vectors of such points for estimating PSF of each block. In the single-image deblurring, the repairing process of a blurred image is performed in a way of block-by-block throughout the image. Finally, temporal information of between consecutive frames is exploited for improving the restoration result. Experimental results show that the proposed method can provide the moderate restoration result of motion-blurred frames.

Keywords: Video Deblurring, Video Restoration, Motion Blur, Point Spread Function, Motion Vector

1. Introduction
Generally, an image sequence will incur blurs during the imaging process owing to various factors, such as air disturbance, machine vibration, motion speed, and equipment settings, etc [1-3]. When a video camera is mounted on a moving vehicle, motion-blur will be incurred into the captured video due to the vehicle’s shaking motion. Basically, the image degradation resulted from motion blur can be described by a convolution model and thus restoration will become a deconvolution process. Many reported motion deblurring methods [4-11] are aimed at single image but only a few methods [12-14] are focused on an image sequence. Most types of motion-blur are regarded as linear and thus the point spread function (PSF) will act as the kernel problem for restoration of a linear motion-blurred image, where blur direction and blur length are two major parameters of PSF. Nevertheless, it is always intractable to obtain the appropriate values of such two parameters or requires a large amount of computations, especially for the real motion-blurred images which are captured in the real situations.
For image restoration based on image degradation model, there are three major approaches: inverse filtering, Winner filtering, and Richardson-Lucy filtering. The basic concept behind the inverse filtering is focused on finding zero points of the periodic function in the frequency domain, but the accuracy of such calculations is easily influenced by noise or requires frequent adjustment for some parameters [4][5]. The spatial-domain-based restoration approach [6] is simple and extracts some local features of a blurred image, such as points, lines, and edges, to estimate parameters of PSF, and hence the required computations are less than that of the frequency-domain-based restoration approach. But, this approach needs to previously know the type of blur, and the accuracy will be significantly degenerated when motion blur is serious.

The basic idea of the frequency-domain-based restoration approach [7] is to calculate zero points of the periodic function in order to identify parameters of PSF, but it is easily influenced by noises. Alternatively, the cepstrum-based restoration approach [8][9] is similar to frequency-based approach in identification of PSF’s parameters but the result will be easily affected by noises. To improve accuracy of identifying PSF’s parameters in the linear motion-blurred images with noises, Radon transform is used to obtain blur direction and the bispectrum modeling is used to derive the length of motion blur [10]. Without using Radon transform or other transforms, a cepstrum-based restoration approach by directly searching the most significant line in the cepstrum is developed for deriving more appropriate parameters of PSF in the real motion-blurred images [11].

In practice, a motion-blurred image sequence usually contains blur frames and clear frames, and even various degrees of blur will exit in different areas of a blur frame. This will make restoration to become more complicated and difficult. A hybrid camera system using a standard video camera that is coupled with an auxiliary low-resolution camera sharing the same optical path but capturing at a significantly higher frame rate is proposed for reducing spatially varying motion blur in video and images [12]. The main strategy of deblurring is to use the data from these two video streams to reduce spatially varying motion blur in the high-resolution camera with a technique which combines both deconvolution and super-resolution. Based on patch-based synthesis, a video deblurring method for hand-held cameras is developed, in which sharp regions in the video is detected and thus used to restore blurry regions of the same content in nearby frames [13]. To avoid visually annoying artifacts due to those blurred frames, a blurred frame is reconstructed utilizing the high-resolution information of adjacent unblurred frames by kernel estimation and residual deconvolution based on a blurred-unblurred frame pair [14].

However, those motion deblurring methods mentioned above may be not suitable for the image sequence in which an image usually contains various areas of blur degrees that is caused by the fast moving object and/or shaky camera. Besides, those methods may be also unallowable for
the real-time applications. To cope with the above problem for the motion-blurred frames, the proposed restoration method involves both single-image deblurring and multi-image deblurring using motion-based point spread function.

2. The Proposed Method of Motion Deblurring

Basically, the proposed motion deblurring method is mainly composed of detection of point spread function estimation, single-image deblurring, and multi-image deblurring, as described in Fig. 1.

![Diagram](image)

Fig. 1: The proposed algorithm of motion deblurring

2.1 Estimation of Point Spread Function

In general, image degradation model is usually used in image restoration for the linear motion blurred images. If such model of image degradation is linear space-invariant and point spread function is consistent on the entire image, a motion blurred image can be described by the following equation.

\[ B = I \otimes PSF + N \]  

(1)

where \( B \) is blur image, \( I \) is original image, \( PSF \) is point spread function, \( N \) is noise, and \( \otimes \) denotes convolution operation.

The major parameters of identifying a point spread function \( psf(x, y) \) of linear motion blur model consists of blur angle and blur length, as illustrated in Eq. (2).
It is noted that the pixel motion between two consecutive frames can be assumed to be linear. As mentioned above, a real motion-blurred image usually contains various blur areas and hence a novel block-based point spread function is developed to improve the restoration of such an blur image. In general, the iteration-based Richardson-Lucy algorithm [15][16] is usually introduced for restoration of a motion-blurred image and thus it requires the initial parameters of PSF.

In the proposed method, the motion vector of each block is used as the initial PSF’s parameters, i.e., motion angle and length are regarded as blur angle and length, respectively. Firstly, a blur image is divided into many blocks and the optical flow method is used to estimate motion vector of each block. Then, each block’s motion vector is employed for deriving PSF parameters of that block. Figure 2 shows each block’s motion vector of a real motion-blurred image, Bicycle, where the upper part is original blur image, the lower part represents every block’s motion vector, and the right part shows the motion vectors of some blocks indicated by red rectangles.

![Fig. 2: Motion vector of each block in Bicycle](image)

### 2.2 Single-Image Deblurring

To repair the blurred image of each block, the blur parameters estimated by exploiting motion vector of each block are used to set an initial PSF for the iterative restoration of the Richardson-Lucy algorithm. Hence, Eq. (1) can be deduced to Eq. (3), in which \( I_{deb}^{(u)} \) is the current deblurred image, \( I_{deb}^{(u+1)} \) is the next deblurred image, \( u \) is the index of iteration number, * denotes correlation operation, and \( M \) means the number of original images \( I_k \) that
construct a blur image $B$. If noise is included and it belongs to Gaussian distribution, Eq. (3) is deduced to Eq. (4).

$$I_{\text{deb}}^{(n+1)} = I_{\text{deb}}^{(n)} + PSF \ast \frac{B}{I_{\text{deb}}^{(n)} \otimes PSF},$$

(3)

where, $B = \frac{1}{M} \sum_{k=1}^{K} I_k$.

$$I_{\text{deb}}^{(n+1)} = I_{\text{deb}}^{(n)} + PSF \ast \left( B - I_{\text{deb}}^{(n)} \otimes PSF \right).$$

(4)

For carrying out Richardson-Lucy algorithm well, $PSF(x, y)$ is viewed as a matrix and normalized, denoted as $PSF_N(x, y)$, according to Eq. (5), where $\Sigma$ indicates sum operation. In point of normalization, every value of $PSF(x, y)$ is between 0 ~ 1 and the sum of all values equals to 1. Thus, $PSF(x, y)$ in Eq. (4) is normalized and the equation is concluded as Eq. (6). Figure 3 shows the restoration result of Bicycle (in Figure 2) by using Eq. (6) in which the initial $I_{\text{deb}}^{(0)}$ adopts the original blur image in the iterative processing. From the figure, it implies that more iterations may not obtain the better restoration result, where the subfigure (a), (b), and (c) show three restoration results $I_{\text{deb}}^{(3)}$, $I_{\text{deb}}^{(6)}$, and $I_{\text{deb}}^{(10)}$, respectively. The reason involves the unreliably initial PSF’s parameters estimated and insufficient information provided in one image. Therefore, temporal information of between consecutive frames is exploited for improving the restoration result, and then a multi-image deblurring technique is developed and will be described in the next subsection.

$$PSF_N(x, y) = \frac{PSF(x, y)}{\sum PSF(x, y)}$$

(5)

$$I_{\text{deb}}^{(n+1)} = I_{\text{deb}}^{(n)} + PSF_N \ast \left( B - I_{\text{deb}}^{(n)} \otimes PSF_N \right)$$

(6)

Fig. 3: Motion vector of each block in Bicycle: (a) $I_{\text{deb}}^{(3)}$; (b) $I_{\text{deb}}^{(6)}$; (c) $I_{\text{deb}}^{(10)}$. 

212
2.3 Multi-Image Deblurring

For achieving real-time deblurring for a motion-blurred image sequence, several reference frames are selected and utilized for improving the appearance of other blurred images. Based on the patch deblurring concept of [13], an enhanced weighting parameter $\omega$ is proposed as described in Eq. (7).

$$
I_{t,x} = \frac{1}{W} \sum_{i=1}^{n} \omega(t,x,t-s,y)B_{t-s,y} 
$$

where $I_{t,x}$ is the deblurred result of pixel $(x, y)$ at frame $t$, $SC(B_{t-s,y})$ denotes the selected reference image, $W$ is the sum of $\omega(t,x,t-s,y)$ and $n$ means the number of selected reference frames.

In the equation, the value of $\omega$ is derived by Euclidean distance between $SC(B_{t-s,y})$ and $B_{t,x}$ and the exponential operation is used to make the weight to be in the range of 0~1. If two pixels are too far, the value of exponential function will approach to zero and thus the value of $\omega$ almost has no contribution to deblurring result.

3. Experimental Results

From the proposed video restoration method for motion-blurred frames described above, the implementation can provide a realistic and interesting evaluation using various image sequences. Figure 4 demonstrates the restoration result of the proposed method using two sequences of Bus and Hand, where the left and right parts of each subfigure represent the original image and restored result, respectively. In these subfigures, it is obvious that the right parts are substantially clearer than the left parts, especially in the edges.

To manifest the superiority of the proposed video restoration method to three reported methods, a comparison in terms of advantage and disadvantage is made in Table 1. From the experimental results, it implies that the proposed method can generate the moderate restoration results of motion-blurred frames in realtime.

4. Conclusion

In this paper, a real-time video restoration method for motion-blurred frames is developed. The basic strategy is to repair the blurred image through block-by-block processing with the blur parameters estimated by exploiting motion vector of each block. For achieving the purpose of real-time video deblurring, several reference frames are selected and utilized for improving the appearance of other blurred images. In the experimental results, the proposed method can’t
obtain better restoration result than some methods for the motion-blurred frames, but it can provide a moderate effect with less computational complexity. Hence, our method may be more attractive than other methods in the realtime applications.

![Figure 4: Restoration result using the proposed method for: (a) Bus; (b) Hand.](image)

**Table 1: Comparison in terms of advantage and disadvantage for four methods**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[12]</td>
<td>Good restoration result (by introducing extra image information)</td>
<td>Require additional auxiliary device</td>
</tr>
<tr>
<td>[13]</td>
<td>Good restoration result for moving object (by extra processing for moving object)</td>
<td>Heavy computational complexity (not easy for realtime application)</td>
</tr>
<tr>
<td>[14]</td>
<td>Good restoration result only for background</td>
<td>Poor restoration result for moving object (only suitable for blurs caused by camera shaking)</td>
</tr>
<tr>
<td>Proposed</td>
<td>Realtime restoration processing</td>
<td>Moderate restoration result</td>
</tr>
</tbody>
</table>

**Acknowledgment**

This work is supported by Ministry of Science and Technology under Grant MOST 104-2221-E-151-008, Taiwan, R.O.C.

**References**


A Novel Seam Finding Method Using Downscaling and Cost for Image Stitching

Jinwook Jeong*, Kyungkoo Jun
Dept. of Embedded Systems Engineering, Incheon National University, Korea
jjw543@inu.ac.kr

Abstract
Seaming finding is an important step for creating panorama images because it smoothes away differences observed at boundaries between stitched images. We propose an improved seam finding method in which we define a cost function to measure the discrepancies boundary pixels causes. We are also able to improve computing complexity by avoiding finding a seam over the whole area of overlapped region. Instead, we use a downscaled version of overlapped area to approximate a seam and then interpolate the seam to the original region. From experiments to generate panorama images, we compare our method with two other existing seam finding algorithms and observe that that our method is able to produce better quality panorama image than the existing methods, while the elapsed time is comparable.

Keywords: Panorama, Image stitching, Seam finding, dynamic programming

1. Introduction
Panorama images contribute to provide realistic experience by having a wider field of view and have various application areas such as CCTV and action cams [1][2][3]. In general, cameras equipped with wide angle lenses are used to capture panorama images, or post processing software creates panorama by stitching multiple images taken by same or different cameras.

Post processing software for panorama generation consists of two steps. The first step is called registration in which feature points are detected and matched between neighbor images to compute parameters such as focal distance and homography. These parameters are then used to warp images to create a large panorama. The second step is blending which balances exposure differences between images and removes seams and ghost effects from moving objects, aiming to remove stitching trace as much as possible [5][6][7][8].

The steps involved in panorama creation depend on various parameter setting, making it harder to create complete and perfect panorama images. Diverse research efforts have been made to improve the quality of resulting panorama. Various blending methods have been proposed [9][10][11][12]. A technique based on Camera motion estimation was proposed to improve the performance of the registration [9]. Seam finding algorithm was proposed by using image
patches obtained by graph-cut algorithm [10]. The performance of seam finding was improved by image segmentation based on watershed algorithm [11]. Dynamic programming technique was able to improve both speed and precision even though it worked on pixel level [12].

This paper proposes a seam finding method for the blending step, which is the second step of the panorama creation. We aim to improve performance while preserving the precision of seam location. For performance, we scale down images by resizing them half size, resulting in less computation time. The seam line that we find in the small sized images is just the approximation of the perfect seam line. Based on the approximation, since the region where the seam line exists is known, we can limit the area where seam finding should be performed rather than applying to whole area. It results in improved performance, while maintaining precision.

This paper is organized as follows. Section 2 describes the proposed seam finding method in detail and Section 3 evaluates the performance of the method and compare with existing methods. And Section 4 concludes the paper.

2. **Downscaling and Cost Function based Seam Finding Method**

We propose to use downscaled images for estimating seam because it is able to reduce time. But it is challenging not to sacrifice precision of resulting seams. The proposed scheme consists of two sequential steps. The first step is to estimate an approximated seam from an overlapped region between two images as shown in Fig.1 (a). Note that before starting seam finding by dynamic programming, we reduce the size of the overlapped area by r times. Thus it has the effect to reduce the computation load and time required for seam finding. However, the resulting seam is just an approximation close to the real seam. In the second step shown in Fig.1 (b), the reduced region is restored back to the original size. During this phase, the seam is also extended, filling up missing parts by interpolation. With the interpolated seam, we set a new area which is within K pixels away from the seam. Then, we are sure that a real seam is contained in the area. Finally, we perform the dynamic programming again over the area to find the real seam.
Figure 2 is the flow chart of the seam finding. We find a seam between two images, $Img_1$ and $Img_2$. At first, an overlapped region between $Img_1$ and $Img_2$ is determined. Then, the sub-image of $Img_1$ is located which belongs to the overlapped region and it is converted to gray scale. We call it Gray$_1$. In the same way, we locate Gray$_2$, the sub-image from $Img_2$. It is obvious that there exists a corresponding pixel within Gray$_2$ for every pixel from Gray$_1$. We call a pixel $i$ of Gray$_1$ and its corresponding Gray$_2$ pixel as $P_i^1$ and $P_i^2$, respectively. And we call $P_i$ the pixel of the overlapped region which has corresponding pixels $P_i^1$ and $P_i^2$.

Then, for every pixel $P_i$, we compute its cost $e_i$. The cost, also called energy, is a real value assigned for each pixel and represents how important the pixel is. Often, gradient or intensity of a pixel is used as the cost. In this paper, we compute $e_i$ as follows.
\[ e_i = \sqrt{(G_i)^2 + (L_i)^2}. \]

\[
\begin{align*}
G_i &= \frac{\|P_i^1 + P_i^2\|}{\max(\|P_i^1 + P_i^2\|)} \\
L_i &= \frac{\|P_i^1 - P_i^2\|}{\max(\|P_i^1 - P_i^2\|)}
\end{align*}
\]

(1)

where \( P_i^1 \) and \( P_i^2 \) are the gradients of \( P_i^1 \) and \( P_i^2 \).

Then, we can obtain a cost matrix \( M_{\text{cost}} \) for the overlapped region. Each element of \( M_{\text{cost}} \) corresponds to \( P_i^1 \) and has \( e_i \) as its value. From \( M_{\text{cost}} \), two other matrices are computed. One is an accumulated cost matrix \( M_{\text{a,cost}} \) and the other is a direction matrix \( M_{\text{dir}} \). By using information from both matrices, we are able to determine where a seam can be drawn without noticeable differences between \( \text{Img}_1 \) and \( \text{Img}_2 \). \( M_{\text{a,cost}} \) is used to find candidate pixels on which a seam is drawn, while \( M_{\text{dir}} \) provides pixel-by-pixel directional information of the seam.

Figure 3 shows how \( M_{\text{a,cost}} \) are made from \( M_{\text{cost}} \). Each element of \( M_{\text{a,cost}} \), \( E(i,j) \), is called an accumulated cost of a pixel at \( i \)th column and \( j \)th row. It is calculated as follows.

\[ E(i,j) = e(i,j) + \min(E(i-1,j-1), E(i,j-1), E(i+1,j-1), E(i-1,j), E(i+1,j)) \]  

(2)

where \( e(i,j) \) is the cost of the pixel at \((i,j)\) from \( M_{\text{cost}} \). \( E(i,j) \) of a pixel is computed by adding its cost to the minimum accumulated cost of its neighboring pixels. Note that among eight neighboring pixels, the three at the lower row are ignored from consideration. Also, the top row pixels do not consider the upper row pixels because they do not exist.

For ease of understanding, we describe step by step how each \( E(i,j) \) is computed. At start, among the top row pixels, we find the pixel with the minimum \( e(i,j) \) and set \( E(i,j) = e(i,j) \) which is the fourth pixel with the value 2 in Fig. 3(a). Then, accumulated costs of neighbor pixels \( E(i-1,j) \) and \( E(i+1,j) \) are computed according to equation (2). This procedure is repeated in a flooding way until all the pixels at the top row are processed, resulting in Fig. 3(b). We then move on to the next row. Note that when calculating \( E(m,n) \), still \( E(m+1,n) \) is not determined yet. Thus we need to iterate twice, however the direction of calculation changes: from left to right first, then right to left as shown in Fig. 3(c): the leftmost subfigure shows left-to-right and the middle one right-to-left, the rightmost the result. Fig. 3(d) shows how the third row is processed. The whole process continues until the last row is finished.
Fig. 3: Process of accumulated cost matrix calculation.
(a) $M_{cost}$, (b) First row calculation of $M_{a.cost}$, (c) Second row calculation of $M_{a.cost}$, (d) Third row calculation of $M_{a.cost}$.

With $M_{a.cost}$, we can determine for $E(i,j)$ which neighboring pixel is selected to contribute to the computation. Fig. 4(a) shows five candidate pixels each given number 1 to 6, except 5 which is reserved for the first pick pixel at the top row. $M_{dir}$ stores for each pixel which neighboring pixel is selected for its $E(i,j)$. For example, Fig. 4(b) shows an example $M_{dir}$ corresponding to Fig. 3(d). Note that the fourth pixel at the top row has the value 5, because no neighboring pixel is considered. The arrows are drawn for ease of understanding.

Fig. 4: Direction description of $M_{dir}$.
(a) Direction of $M_{dir}$, (b) Example of $M_{dir}$.

Once completing $M_{a.cost}$ and $M_{dir}$, a seam can be determined. It starts from the bottom row and moves up in an anti-arrow direction, drawing a seam over visited pixels. To describe the procedure in detail, among the pixels on the last row of $M_{a.cost}$, we select the one with the minimum $E(i,j)$.
Then, we follow the arrow in a reverse way to move to one of the neighboring pixels, for this we use the direction information from \( M_{dir} \). Finally, if all visited pixels before reaching the final pixel as the top row are connected, it becomes a seam. Since the seam consists of only the pixels with least distinction, the resulting boundary provides smooth transition between two images.

There is an unusual case in which more than one pixel has the minimum cost at the top row in \( M_{cost} \). In this case, we cannot avoid increasing computation load, because for each pixel, we compute \( M_{a, cost} \) and \( M_{dir} \) independently and separately. Thus, we produce multiple sets of resulting matrices. However, we choose only the set of which \( M_{a, cost} \) contains the least value \( E(i,j) \) at its bottom row, ignoring the rest. Then, the seam determination is processed in the same way as explained.

3. Performance evaluation

We evaluate the performance of the proposed scheme through experiments that create panorama images by stitching multiple overlapping images. In the experiments, we observed and compared the resulting stitching quality between the proposed method and existing methods. A representative seam finding algorithm [7] based on dynamic programming and a scheme depending on graph cut [8], and a Voronoi diagram method were chosen for comparison. We refer the former as the seam finding, the latter the graph cut.

We used four different sets of test images. Each set consists of two overlapping images each corresponding to left and right. Each image has the resolution of 640 * 480. We used the computer with the following specification for the experiments and implemented our algorithm by using an open source library, OpenCV 2.4.9 [13], with the parameter r and K set 3, 40, respectively.

<table>
<thead>
<tr>
<th>Table 1: Experiment PC specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor:</td>
</tr>
<tr>
<td>Memory:</td>
</tr>
<tr>
<td>OS:</td>
</tr>
</tbody>
</table>
which they are stitched together. We select the test images such that overlapping areas are different features.
Figure 6 shows the stitching results of test image (a). Fig. 6 (a), (b), (c), and (d) are the results of the dynamic programming, the graph cut, the voronoi diagram, and the proposed method, respectively. We can observe that in all the methods except our method, the rail installed on the ceiling is not continuous, and a similar discrepancy is also found at the chair leg on the floor. However, the result of the proposed scheme is free from those flaws.
Figure 7 shows the stitching results of test image (b). Fig. 6 (a), (b), (c), and (d) are the results of the dynamic programming, the graph cut, the voronoi diagram, and the proposed method, respectively. We can observe that in all the methods except our method, the rectangular pillar in the middle has a very large mismatch. However, the result of the proposed scheme is free from those flaws.

Figure 8: Result comparison of seam finding methods for the test image (c): (a) Dynamic programming, (b) Graph cut, (c) Voronoi diagram, (d) Proposed method.
Figure 8 shows the stitching results of test image (c). Fig. 8 (a), (b), (c), and (d) are the results of the dynamic programming, the graph cut, the voronoi diagram, and the proposed method, respectively. We can observe that in all the methods except our method, each image has a similar discrepancy at the top middle part and also at the lower middle part. However, the result of the proposed scheme is free from those flaws.
Figure 9 shows the stitching results of test image (d). Fig. 8 (a), (b), (c), and (d) are the results of the dynamic programming, the graph cut, the voronoi diagram, and the proposed method, respectively. We can observe that all the methods show similar results without noticeable flaws or mismatches.

Figure 10 shows the elapsed times for the methods. Given a same video as input to each method, we measured the times consumed for stitching each frame. The voronoi diagram was the fastest with average 2.6 msec, while the graph cut was the slowest with average 52.5 msec. The proposed method scored 36.1 msec which was better than the graph cut but was slower.
than the others. However, considering that the resulting panorama quality of the proposed method is superior to the others, the increased time was spent for Gaussian filtering, entropy calculation to improve the results.

4. Conclusions

We proposed an improved seam finding method which is important to smooth out the boundary of stitched images in panorama creation. For this, we defined a cost function to determine how each pixel affects stitching results. We were also able to reduce time consumption; instead of finding a seam over the whole area of overlapped region, we worked on a downscaled version of the overlapped image and interpolated to the original size. We carried out panorama creation experiments in which our method as well as existing seam finding algorithms was used. Resulting panorama image quality was superior when our method was used, while the elapsed time of our method was comparable.

5. References


ICEAI-1080
A Heuristic for Maximizing the Lifetime of Data Aggregation in Wireless Sensor Networks

Bing-Hong Liu\textsuperscript{a*}, Van-Trung Pham\textsuperscript{b}, Ngoc-Tu Nguyen\textsuperscript{a}, Yi-Sheng Luo\textsuperscript{a}
\textsuperscript{a}Department of Electronic Engineering, National Kaohsiung University of Applied Sciences
415, Chien Kung Rd., Kaohsiung 80778, Taiwan
\textsuperscript{b}Department of Information Technology, Pham Van Dong University
99, Hung Vuong Rd., Quang Ngai 57000, Viet Nam
bhliu@kuas.edu.tw

Abstract
Recently, many researchers have studied efficiently gathering data in wireless sensor networks to minimize the total energy consumption when a fixed number of data are allowed to be aggregated into one packet. However, minimizing the total energy consumption does not imply the network lifetime is maximized. In this paper, we study the problem of scheduling data aggregation trees working for different time periods to maximize the network lifetime when a fixed number of data are allowed to be aggregated into one packet. In addition, we propose a heuristic to balance the lifetime of nodes in data aggregation trees such that the network lifetime is maximized. Simulation results show that the proposed heuristic provides a good performance.

Keywords: Wireless sensor network; data aggregation tree; network lifetime.

1. Introduction
Wireless sensor networks (WSNs) consist of many wireless sensors, where sensors are often deployed in a wide range of field. Today, many applications of WSNs have been developed, such as surveillance monitoring, seismic monitoring, and fire detection [1], [2], [3]. In these applications of WSNs, one of the most important operations is data gathering. The data-gathering mechanism in WSNs is responsible to collect sensed data from sensors and report the data to a specific node, called the sink. In this paper, we study prolonging the lifetime of WSNs with efficient data gathering.

Tree is a well-known structure that can lead the generated data to the sink in WSNs. With tree structures, each node in the tree is responsible for receiving data from its child nodes and forwarding its generated or received data to its parent node. Recently, many studies investigate designing data gathering trees to maximize the lifetime of WSNs. In [4], the problem of choosing a maximum lifetime tree from a set of shortest path trees is studied. In [5], to solve the maximum lifetime data collection problem in sensor networks, an approximation method
that uses intelligent selection of trees is proposed. In [6], when a single sink exists, an approximation algorithm of constructing a spanning tree to prolong the network lifetime is proposed. In the studies [4], [5], [6], the data are directly forwarded through the tree to the sink without aggregating data, and therefore, lots of energy is spent for data gathering.

To minimize the energy consumption for data forwarding, data aggregation is often used to minimize the size of forwarding data [7], [8], [9]. A data aggregation tree is thus used to prolong the network lifetime while data are allowed to be aggregated. In addition, some sensors in WSNs, called source nodes, are responsible for sensing the environment and generating sensing data; and some sensors, called relay nodes, can be used to forward received data to others. When any source node depletes its energy, the end of the network lifetime for the WSN is reached because the network cannot provide adequate quality of service for applications. To prolong the network lifetime, a set of data aggregation trees that work in turn for different time periods can be applied in WSNs. This motivates us to study the problem of scheduling data aggregation trees for different time periods when a fixed number of data are allowed to be aggregated into one packet such that the network lifetime is maximized.

The rest of this paper is organized as follows. Section 2 describes the details of the network model. Section 3 proposes the proposed heuristic. In Section 4, the performance of the proposed heuristic is evaluated in terms of the network lifetime in WSNs. In Section 5, this paper is concluded.

2. System Model and Assumptions

In this paper, the communication model in the wireless sensor network is assumed to be a unit disk graph model [10]. In this model, a sensor u can receive messages from sensor v if u is within the transmission range of v. Hereafter, u is said to be v’s neighboring node in the network if u can receive messages from v. When all sensors have the same transmission ranges, the WSN can be represented as a connected weighted graph \( G(V_G, E_G, w_G, \rho_G) \), where node \( v \in V_G \) represents a sensor in the WSN, edge \( (u,v) \in E_G \) represents that u and v can communicate with each other, \( w_G(v) \) represents the energy of v, and \( \rho_G(v) \) represents the number of units of raw data generated by v to report to sink s \( \in V_G \) per unit time, where the sink s is a special node in the network and is responsible for data collecting, processing, and analysis. The data generated in a unit time have to be reported to the sink in the same unit time, which is called a working round hereafter. In addition, the nodes v with \( \rho_G(v) > 0 \) are called source nodes; and the nodes v with \( \rho_G(v) = 0 \) are called relay nodes. Note that the relay node can receive data from other nodes and forward the received data to the next node for reporting data to the sink. In addition, the source node can generate its own raw data for each working round and works like a relay node to help relaying data.
A data aggregation tree constructed for the network $G$ is a spanning tree $T = (V_T, E_T)$, where $V_T = V_G$ and $E_T \subseteq E_G$. A data aggregation tree $T$ has to satisfy that $T$ is a connected graph rooted at the sink without cycle. In addition, the data generated by source nodes in $G$ are required to be forwarded to and collected in the sink via $T$. Because each node $u$ in a data aggregation tree $T$ has to forward its generated or received data to its parent node in $T$, $u$ has to help forwarding all data generated in the subtree rooted at $u$. Let $u.tot$ denote the total number of units of raw data generated and received by $u$. Also let $u.T.CH$ denote the set of $u$’s child nodes in $T$. Then $u.tot$ can be calculated by the following equation:

$$u.tot = \rho_G(u) \sum_{v \in u.T.CH} v.tot$$ \hspace{1cm} (1)$$

Assume that raw data generated in the WSN can be aggregated in each node in $T$. Let $\alpha \in \mathbb{Z}^+$ ($\alpha \geq 2$) be the aggregation ratio, representing the maximum number of units of raw data allowed to be aggregated into one unit-size packet [7], [8], [9]. The number of unit-size packets that are forwarded by each node $u$ in $T$, denoted by $u.\delta$, can be calculated by the following equation:

$$u.\delta = \left\lfloor \frac{u.tot}{\alpha} \right\rfloor$$ \hspace{1cm} (2)$$

Let $e_{rx}$ (or, $e_{rx}$) represent the energy consumption of a sensor node to transmit (or, receive) one unit-size packet. Because each node $u$ in $T$ has to receive packets from its child nodes in $T$ and forward the aggregated data to its parent node in $T$, the energy consumption for node $u$ in $T$ to receive and forward data within each working round is therefore calculated by the following equation:

$$u.eng = e_{rx} \sum_{v \in u.T.CH} v.\delta + e_{tx} u.\delta$$ \hspace{1cm} (3)$$

In WSN, each node $u$ has limited energy $w_0(u)$ to maintain its activity. The lifetime of $u$, represented by $u.\ell$, is therefore defined by the maximum number of working rounds for $u$ to sustain [11], [12], [13], calculated by the following equation:

$$u.\ell = \left\lfloor \frac{w_0(u)}{u.eng} \right\rfloor$$ \hspace{1cm} (4)$$

In a data aggregation tree $T$, every node has to help forwarding the aggregated data to its parent node in $T$. Therefore, the lifetime of $T$, denoted by $T.\ell$, is defined as the minimum $u.\ell$ for all $u \in T$, as calculated by the following equation:

$$T.\ell = \min(v_1.\ell, v_2.\ell, ..., v_k.\ell)$$ \hspace{1cm} (5)$$

where $v_1, v_2, ..., v_k \in T$. Because a set of data aggregation trees, $T_1, T_2, ..., T_p$, can work in turn for time periods $t_1, t_2, ..., t_p$, respectively, the data aggregation trees can be employed to prolong the network lifetime. The network lifetime is thus calculated by the sum of the lifetime of all scheduled data aggregation trees, that is, $\sum_{i=1}^{p} T_i.\ell$. Therefore, our problem is to schedule data aggregation trees for different time periods when a fixed number of data are
allowed to be aggregated into one packet such that the network lifetime is maximized.

3. Proposed Heuristic

In this paper, a heuristic is proposed for the problem of scheduling data aggregation trees for different time periods such that the network lifetime is maximized. The idea of the proposed heuristic is to find a data aggregation tree with maximum lifetime for any WSN when a new data aggregation tree is required for the network. In the proposed heuristic, a shortest path tree $T$ is first constructed to span all nodes in the WSN because the path from any node in the tree to the sink is the shortest. For the purpose, while given a wireless sensor network $G$, a breadth-first-search method [14] can be used to construct a shortest path tree $T$ to span all nodes in $G$.

After constructing a shortest path tree $T$ in the network $G$, our idea is to rebuild the tree structure $T$ such that the nodes having little or no energy become leaf nodes. This is because a leaf node in a tree does not need to relay other nodes’ data, that is, the leaf node wastes energy only on transmitting its generated data. When a non-leaf node in $T$ is changed to a leaf node, the node can save its energy on forwarding data.

After transferring the non-leaf nodes having little or no energy into leaf nodes in $T$, we then check every node $u$ in $T$ to see if a local adjustment can be made to prolong the lifetime of $u$’s parent node in $T$. Let $u$’s parent node be $x$. Also let $v$ be the neighboring node of $u$ in the network $G$ such that $v.h_T = u.h_T - 1$ and $v$ is not $u$’s parent node in $T$, where $v.h_T$ (or $u.h_T$) denotes the minimum hop count from the sink to $v$ (or $u$) via the tree structure $T$. We check that if the parent node of $u$ is changed from $x$ to $v$ and the lifetime of $u$’s parent node in $T$ is therefore prolonged, edge $(u,v)$ is inserted into $T$ and edge $(u,x)$ is deleted from $T$.

4. Performance Evaluation

In order to evaluate the performance of the proposed heuristic, the simulations are performed by using DevC++ modeler environment. In this section, the scenario and the parameters used for the simulations are presented in Section 4-A. In addition, the results of performance evaluation of the proposed heuristic are presented in Section 4-B.

A. Scenario and the Parameters

Here, simulations were conducted to evaluate the performance of the proposed heuristic. In the simulation, the WSNs were generated by randomly deploying sensors when the number of nodes ranging from 200 to 1000 including source nodes and 50 relay nodes deployed in a $10 \times 10$ field. In addition, the transmission range and the initial energy of each sensor was set to 2 and $10^5$, respectively. Because the transmission power is about double the reception power [8], $e_{tx}$ and $e_{rx}$ were set to 2 and 1, respectively. The numbers of units of raw data generated by

232
source nodes per unit time were randomly selected from the interval [1,10]. In the following simulation, 100 WSNs were generated. In addition, the simulation results were obtained by averaging the data of 100 networks. In the simulation, a shortest-path-tree-based scheduling algorithm (SPTBSA) was introduced here to compare with the proposed heuristic in terms of the network lifetime.

### B. Network Lifetime

Fig. 1 shows the simulation results for the network lifetime versus the number of network nodes. It is clear that when the number of network nodes increases, the network lifetime of the proposed heuristic and the SPTBSA decreases. This is because more source nodes exist in the networks, and more data must be relayed to the sink. Therefore, more energy must be consumed in some critical nodes. In addition, our method have a longer network lifetime than that of the SPTBSA. This is because the lifetime of critical nodes is prolonged our proposed heuristic.

![Figure 1. The network lifetime versus the number of network nodes ranging from 200 to 1000.](image)

### 5. Conclusion

In this paper, we study the problem of scheduling data aggregation trees for different time periods when a fixed number of data are allowed to be aggregated into one packet such that the network lifetime is maximized. In addition, we propose a heuristic for the problem. In the proposed heuristic, we find a data aggregation tree with maximum lifetime for any WSN when a new data aggregation tree is required for the network. While finding a data aggregation tree, a shortest path tree is constructed to be the data aggregation tree to span all nodes in the WSN. Then, the tree structure is rebuilt such that the lifetime of the data aggregation tree can be maximized. The simulation results show that our proposed heuristic provides a good
performance.

Acknowledgment

This work was supported by the Ministry of Science and Technology under Grant MOST 104-2221-E-151-014.

References


Student Authentication Method by Update of Face Information in e-Learning System

Taisuke Kawamata\textsuperscript{a*}, Susumu Fujimori\textsuperscript{b}, Takako Akakura\textsuperscript{b}

\textsuperscript{a} Graduate School of Engineering, Japan
\textsuperscript{b} Faculty of Engineering Division, Japan
kawamata_taisuke@ms.kagu.tus.ac.jp

1. Background
E-Learning utilizing video lectures is effective in easing restrictions of time and space. However, there is a problem that student’s spoofing may occur during a lecture by e-Learning. To solve this problem, we investigated face authentication method to make sure whether a student is the same person from beginning to end during e-Learning.

2. Method
We devised the authentication method with sequential updates of student’s face information for collating using newly input images taken by a web-camera during the e-Learning, and named this method "update method". It is expected that the update method enables to make sure whether a student is the same person from beginning to end during e-Learning by inputting a newly taken face information in certain timing and matching it with the previously input face information. We examined the update timing and procedure in this paper.

3. Expected Result
In order to check the performance of the update methods, we took frontal images of students during e-Learning by experiment. We applied the update methods to those images, and investigated the difference in the degree of similarity on spoofing. The result suggest that the spoofing is detectable by focusing the degree of similarity into a certain range. In addition, we evaluated the authentication accuracy of update methods using database which consists of about 40,000 face images for 34 people. The error equal rate (EER) was improved by more than 0.05 and update methods were shown to be useful. With regard to the update timing, the frequent update of the face information makes the false reject rate (FRR) low, while makes the false accept rate (FAR) high. In the case that the update timing is restricted to the time when a student operates e-Learning system, the authentication accuracy becomes highest. It is also found that adding a face feature vector to each other makes the authentication accuracy higher than overwriting the an input face image onto a face image for collating.

Keywords: e-Learning, Video lecture, Student authentication, Face image
Energy Engineering

Wednesday, May 11, 2016  13:00-14:30  Room 1005

Session Chair: Prof. Sedat Yayla

ICEAI-1072
Rectangular Shifted Tabs for Supersonic Jet Control
Maruthupandiyan K | Indian Institute of Technology Kanpur
Rathakrishnan E | Indian Institute of Technology Kanpur

ICEAI-1175
The Separation of Water and Oil in Water Treatment Plant in Petroleum Project Using Coalescing Plate Seperator and CFD Simulation
Sedat Yayla | Yuzuncu Yil University
Soran Sabah Ibrahim | Yuzuncu Yil University
Ali Bahadir Olcay | Yeditepe University

ICEAI-1179
Hi-Way Flow Channel Method in Shale Gas Development: A Breakthrough of Environmental Impact towards Hydraulic Fracturing
Andreas Franzona Pangaribuan | Padjadjaran University
Damian Pascal Ginting | Padjadjaran University
Edy Sunardi | Padjadjaran University

ICEAI-1194
Effect of Operation Condition on Moisture Removal in a Desiccant Cooling System
Irfan Uckan | Yuzuncu Yil University
Tuncay Yilmaz | Osmaniye Korkut Ata University
Orhan Buyukalaca | Osmaniye Korkut Ata University

ICEAI-1221
Ventilated Truncated Tabs for the Passive Control of Supersonic Elliptic Jets
Saif Akram | Indian Institute of Technology Kanpur
Ethirajan Rathakrishnan | Indian Institute of Technology Kanpur
ICEAI-1079
Experimental Study of The Evaporation Characteristics of A Binary Fuel Droplet in Rapid Compression Machine Conditions
Jonghan Won | Korea Advanced Institute of Science and Technology
Seung Wook Baek | Korea Advanced Institute of Science and Technology
Hyemin Kim | Korea Advanced Institute of Science and Technology
Hyeongjin Ahn | Korea Advanced Institute of Science and Technology
ICEAI-1072
Rectangular Shifted Tabs for Supersonic Jet Control

K.Maruthupandiyana, ERathakrishnanb

a Ph.D. Student, Department of Aerospace Engineering, Indian Institute of Technology Kanpur, India.
b Professor, Fellow of Royal Aeronautical Society, Department of Aerospace Engineering, Indian Institute of Technology Kanpur, India.
maruthu@iitk.ac.in

Abstract

An experimental investigation has been carried out with the objective of promoting jet mixing, without thrust loss. With this aim the mixing characteristics of Mach 2 jet issuing from circular convergent-divergent nozzle has been studied at different levels of expansion at the nozzle exit. Two identical rectangular flat tabs of aspect ratio (length/width) 3, 4, 5 and 6, offering 2.5% blockage each, located diametrically opposite, at axial locations 0.25D, 0.5D and 0.75D downstream of the nozzle exit has been studied. It has been found that the mixing promotion caused by the shifted tab increases with increase of adverse pressure gradient (i.e. below NPR 5). On the contrary the mixing enhancement caused by tab placed at the nozzle exit decreases with increase of adverse pressure gradient. At higher NPRs from 5 to 8 for shifted tab configuration, the magnitude of oscillation in centerline pitot pressure is reduced considerably compared to the uncontrolled jet. It is been found that, at lower NPRs, that is, in the presence of high level of adverse pressure gradient, corresponding to expansion level from \( \frac{p_e}{p_a} = 0.383 \) to 0.511, shifted tab is found to be a better mixing promoter than the tab at the nozzle exit. Thus for expansion level from \( \frac{p_e}{p_a} = 0.511 \) to 1.022, the tab at the nozzle exit found to be better mixing promoter. Also, among the shifted tab locations, 0.5D is found to be the best mixing promoter, resulting in 57.1% reduction of core length at NPR 3 and the corresponding core length reduction for tabs at 0.25D, 0.5D and 0D are 54.3%, 37.1% and 25.7%, respectively.

Keywords: Uncontrolled jet, shifted tab, adverse pressure gradient, core length.
ICEAI-1175
The Separation of Water and Oil in Water Treatment Plant in Petroleum Project Using Coalescing Plate Seperator and CFD Simulation

Sedat Yayla \textsuperscript{a}, * Soran Sabah\textsuperscript{a} Bahadir Olcay\textsuperscript{b}
\textsuperscript{a}Yuzuncu Yil University ,Van, Turkey \\
\textsuperscript{b}Yeditepe University ,Istanbul, Turkey \\
bahadir.olcay@yeditepe.edu.tr

Abstract
This study utilized computational fluid dynamics CFD simulation two dimensions by corrugated plate to investigate the effect of space between plates, orifice diameter and velocity on separation efficiency. Various spacing between plates 8, 12, 16, 20, 24mm orifice diameter of coalescing plate on 10, 15, 20 mm with different shape such as rectangular, cylindrical and ellipse and four different velocities 0.02, 0.03, 0.04, 0.05 m/sec have been investigated on to find the effect of each diameters on the oil removal efficiency. The study revealed that the increase in the distance between plates have negative correlation on the oil removal efficiency. Moreover the increase in the t of the mixture or mass flow rate inlet also has negative correlation on the oil removal efficiency. It is also discovered that the best separation efficiency was cylindrical shape with orifice diameter of 15 mm. The oil removal efficiency result was varied between 25% to %99.25 relying on the use of different distance between plates and velocities.

Keywords: CFD, two-phase flow, velocity of mixture, oil-water separation efficiency, coalescing plate.

1. Introduction
The water, which is produced and brought to the surface with natural gas and crude oil, is polluted. In the production of hydrocarbon, it is derived to the superficial as an example of produced fluid mixing. The biggest waste by volume in oil production process is water (Razi F.A. et al., 2009; Razi F.A. et al., 2010; Hashim R. et al., 2009) The compound of the fluid mixture relays on how crude oil or gas is generated. In spite of the fact that it usually contains either ,gaseous hydrocarbon or liquid ,suspend or dissolved solids, settling like sand or slt, and inserted fluids and additives added to the composition through the introductory phase and following production activities (John A. et al., 2004) Because of the high level of the toxicity and solubility in the remained water, it enlarges a major environmental risk for mankind (Zhaohui X. et al., 2003). There is testimony that hydrocarbon can give the rise to cancer and other serious diseases, in accordance with the U.S. environmental protection agency (Agency
USEP, 1998). That is why decreasing exposure to these materials is fundamental for preserving marine and human life. (Reusser D.E. et al., 2002)

In the oil manufacturing industry, generated water is the main volume waste stream. The ratio of water to oil is nearly 3:1. (Halliburton, 2010) It subsists as a result of manufacturing gas and oil from subsurface tanks. (James P.R. et al., 1993) The world evaluated an average of generated water is around 200 million bbl./day a mounting in early production to more than 70 bbl./year. (Khatib Z. et al., 2003) The amount of water produced from the oil manufacturing process has augmented sensationally and it is not stable through an oils operation time. It is proven that there is a negative correlation between water production and oil (Razi F.A. et al., 2009). It a number of older fields, the water could surpass more than 90 % (Ling L.P. et al., 2006; Halliburton, 2010). Globally, the amount of water production is anticipated to rise in the upcoming days. This states that the influence of disposing manufactured water into the ecosystem will be an immense concern (Halliburton, 2010). The corrugated plate separator system is the main formation of separation gravity. This apparatus utilizes the variances in densities among water and oils as a standard separation method. The unit can be a lone plate or three sheets or may comprise a nest of symmetrical plates, which is normally 10–20 mm wide. The operative important of plate systems are to permit oil globules move to a plate superficial where coalescence can happen and to form bigger oil globules, which are at ease to separate (Guerin T.F., 2002). Coalescing plates explains a new separating system which has multiple angle parallel coalescence frustums for extracting emulsified and free oils from polluted water. The principle part of the separator consists of a sequence of upright and inverted frustum formed coalescence plate to configure and multiple angle plot array to improve the separation gravity and coalescence of oil globules. The study found that the existence of outlet baffle compartment for without out let baffle plate. (Ling L.P. et al., 2006)

Fig. 1: Module of Coalescing Plate Separator (Ivanenko et al., 2010)

2. Material
A computational fluid dynamic (CFD) code such as ANSYS-FLUENT necessitates definition of geometry, mesh, and solver settings to compute the necessary outcomes. The procedure of the modeling and simulation gradually from pre-processing, to post-processing phases are designated correspondingly. ANSYS-FLUENT is utilized in the present study. A series of CFD simulations as a parametric study is utilized to define the effects of changing geometry parameters such as diameters, flow parameters, and distance between plates.

For any simulations, the volume of fluid (VOF) model is a very important step, because it involves the preliminary concept and creation of the model. (VOF) Model is created by Designing modular in ANSYS Workbench in this study. The geometry is then meshed by applying ANSYS meshing platform. The physical characteristics like viscosity, density, and boundary conditions such as velocity and volume fraction of water are defined (Ansys fluent guide, 2009).

The creation of the flow geometry is the first step in simulating any engineering flow, which can be created by utilizing ANSYS Design Modular in ANSYS workbench, or any CAD software. Then, export it to the ANSYS workbench. For the present study, the geometry was created by using ANSYS Design Modular in ANSYS workbench application. There are two steps to create geometry regions. Firstly, a pyramid sketch is created on the base plane XY. Since the flow is accepted in X direction. The length of the pyramid or triangle is 80 mm and the height of 30mm and two dimensions of orifice diameter are used (10mm and 15mm). Ten types of geometries were used and the distance between plates was 8, 12, 16, 20, 24mm. The second step is the creation of a slice on XY plane to take the boundary surrounding the shape. In the system the left side called inlet, when the fluid entered the system and the top and bottom of the boundary called wall and the end of boundary is called outlet. The mixture entering the plate has a volume of fraction water - oil is 3:1.

Separation equation expressed by (Abdurrahman H. et al., 2007; Amtzen R., 2001). Separation efficiency equation (%) = (WI - WO)/WI (Razi F.A. et al., 2009)

WI = water inlet oil content.
WO = water outlet oil content.

The equation of continuous equation in the two phase flow phase is described as (δu/δx) + (δv/δx) = 0 (Ansys fluent guide, 2009; Zhao J. et al., 2007; Razi F.A. et al., 2010)
The conservation rules of mass, energy and momentum during homogeneous flow can be
derived in expression of the velocity for each phase $u_1$ and $u_2$, and area phase one $A_1$, area
phase two $A_2$ (White F., 1997).

\[
\begin{align*}
  u_m &= u_o + u_w \\
  u_w &= \rho_1 u_1 A_1 \\
  u_o &= \text{Mass flow rate mixture kg/sec} \\
  u_o &= \text{Mass flow rate oil kg/sec}
\end{align*}
\]

Density is one of the physical properties of matter, as each compound and element has a unique
density related with it. Density definite in a specific style as the measure of the relative
weightiness of an object with a constant volume.

\[\rho = \frac{M}{V} \quad \text{(Hashim R. et al., 2009)}\]

M weight (kg)  
V volume (m$^3$)

Momentum equation is expressed by (Ansys fluent guide, 2009)

\[
\frac{\partial}{\partial t}(\rho v) + \nabla \cdot (\rho v u) = -\nabla p + \nabla \cdot [\mu (\nabla v + \nabla v^t)] + \rho g + F
\]

(John et al., 2004)

Mass flow rate equation Mass flow from each phase $= \rho \text{phase} \times \text{area phase} \times V$

(Zhaohui X. et al., 2003)

C is the coefficient of hydraulic resistance during flowing around the drop; in the laminar mode
(Ivanenko A. et al., 2010).

C = $24/Re$ (Agency USEP, 1998)

The volume of fraction equation and volume of fluid is expressed by (Ansys fluent guide, 2009).

\[
\frac{1}{\rho q} \left[ \frac{\partial}{\partial t} (a q \ast \rho q) + \nabla \cdot (a q \ast \rho q \ast v q) \right] = S a q + \sum_{p=1}^{\frac{\pi}{2}} (m p q - m q p)
\]

(Reusser D.E. et al., 2002)

$aq = 0$ Meaning that the cell is unfulfilled

$aq = 1$ Meaning that the cell is full

$0 < aq < 1$ Meaning that the cell comprises boundary among two fluids such as water and oil
3. Results And Discussion

The use of coalescing plates in the removal of oil from water is a commonly used method in industry. However, determination of separation efficiency can be difficult to measure depending on the varied parameters. In the present study, a two-dimensional computational fluid dynamics model was prepared to simulate removal process of oil from water in coalescing plates system.

Figure 4 indicates that when the velocity laminar flow inlet is 0.0400 m/sec and the distance between plates is 16mm the stream line velocity arises in a curvilinear channel to 0.13504m/sec. The region of the whirl flow occurs in the curvilinear channel and in the orifice diameter of the plate.

Figure 5 express the rise of velocity vector 0.13504 m/sec when using the distance between plate16 mm compared to the velocity of the mixture inlet to 0.0400 m/sec. This is caused by the impairment of velocity vector in the coalescing plate. It is important to notice that in all
conditions the velocity vector is higher than the velocity of mixture flow inlet which is very crucial for separation process. The result of this research agrees with (Ivanenko A. et al., 2010).

Figure 6 displays that using the velocity of mixture inlet 0.0300m/sec and the distance between plates 16 mm results in the rise of the x-velocity to 0.08630 m/sec, the most fundamental part is that the x-velocity is higher than the velocity of mixture flow inlet.

![Velocity Vector When H=16 When Velocity 0.0400 m/sec.](image)

![Velocity In X-Direction When H = 16 And Velocity = 0.03 m/sec.](image)

Figure 7 expresses that applying the velocity of mixture inlet 0.0300m/sec and the distance between plates 16mm increased the y-velocity to 0.06843m/sec. The high vertical velocity (y-axis) assists the separation of bulk phase and globule phase. The outcome of this study agrees with the result of (Mastouri R., 2010; Ivanenko A. et al., 2010).
Figure 8 indicates that when the velocity of the mixture inlet is 0.0300 m/sec) and the distance between plates is 16 mm, the velocity magnitude rises to 0.10234 m/sec. This variation in the velocity leads to the occurrence of the separation in the coalescing plate. It is important that the velocity magnitude must be higher than the velocity of mixture flow inlet. The velocity magnitude consists of x-velocity and y-velocity. Velocity magnitude is bigger than the velocity of mixture inlet which causes the fluid to be separated.

Figure 9 indicates that when the oil volume of fraction is 0.28616 % and applying the distance between plates 24 mm, the separation efficiency is 24.00%. When the layer of oil is invisible in the water outline indicates high separation efficiency. Conversely, when the oil layers obviously displays in the water outline indicate law separation efficiency.
Figure 10 explains the relation between separation efficiency and distance between plates. When distances between plates increased from 8 to 24mm and the velocity of mixture inlet increased from 0.0200 to 0.05m/sec the separation efficiency decreased from 99.25% to 24%. However, there is a rapid decrease in separation efficiency when distance between plates increased from 12mm to 24mm. In this study various spacing is studied 8, 12, 16, 20, 24mm. the study revealed that the smaller the space between plates the better the separation efficiency.

Figure 11 describes the relation between separation efficiency and the mixture velocity inlet. When the mixture velocity inlet increased from 0.0200 to 0.0500m/sec and the separation efficiency decreased from 99.25% to 52.47%. Nevertheless, the separation efficiency was rapidly decreased when the velocity increased from 0.0300 to 0.0500m/sec, meaning that the inversely correlation between velocity inlet and separation efficiency.
Figure 12 shows the relation between separation efficiency and the mass flow rate inlet. The velocity of mixture inlet increased from 0.0200 to 0.0500 m/sec and the distance between plates was 8 to 24 mm, the mass flow rate increased from 0.29288 to 2.194 kg/sec. The separation efficiency decreased from 99.25% to 24.00%. Nevertheless, the separation efficiency was rapidly decreased when the velocity mass flow rate increased from 0.659004 to 2.194 kg/sec. This expresses that there is an inverse correlation between mass flow rate inlet and separation efficiency.

4. Conclusions

In the present research, an investigation is carried out to have an understanding on the oil-water two phase flow phenomenon in coalescing or corrugating plate and its separation. The study supply’s an outline with utilizing computational fluid dynamic CFD simulation program and selected volume of fluid VOF oil-water phase’s model.
In this study factors like orifice diameter, velocity, volume of fraction, distance between plates and separation efficiency have been monitored. It is discovered that the oil removal efficiency is inversely proportional with velocity and mass flow rate inlet. Furthermore, the smaller the spacing between plates is, the better the separation efficiency. The study focused on several orifice diameters such as 10, 15, 20 mm and various shape such as rectangular, ellipse and cylindrical. It is discovered that the best separation efficiency was by utilizing coalescing plates which has cylindrical shape with an orifice diameter of 15 mm diameter.

5. References


Ansys fluent guide (ANSYS FLUENT), theory and guide in 2009.

Computational analysis for multi-phase flow in helical water oil separator using (CFD) Submitted to the College of Graduate Studies (2006). Texas A&M University-Kingsville in partial fulfillment of the requirements for the degree of master science may.


R. Mastouri (2010). A time to review the produced water treatment technologies, a time to look forward for new management policies. Islamic Azad University, Arak Branch Civil Engineering Faculty, Daneshgah Street Arak, Iran.
ICEAI-1179
Hi-Way Flow Channel Method in Shale Gas Development: A Breakthrough of Environmental Impact towards Hydraulic Fracturing

Andreas Franzona Pangaribuan1*, Prof. Edy Sunardi2, Damian Pascal1
1 Departement Geology Engineering, Padjadjaran University
2 Guidance Lecture, Departement Geology Engineering, Padjadjaran University
Jl. Raya Bandung – Sumedang Km 21 Jatinangor 45363
andreaspangaribuan1@gmail.com

Abstract
Fuel, which is categorized as conventional reservoir, now has been diminished. Many innovations have also been developed to overcome this problem. Nowadays, unconventional reservoirs have become the main spotlight in several countries. One of the most popular among them is shale gas reservoirs. Shale gas refers to natural gas that is trapped within shale formations. Over the past decade, shale gas development in Indonesia is still stagnant. It caused by some problems, one of them is hydraulic fracturing process that is associated with environmental issues. Hydraulic fracturing, or “fracking”, is the process of drilling and injecting fluid into the ground at a high pressure in order to fracture shale rocks to release natural gas inside. The water used in injecting fluid process is mixed with sand and chemicals to create fracking fluid. Up to 600 chemicals are used in fracking fluid, including known carcinogens and toxins such as uranium, mercury, ethylene glycol, methanol, hydrochloric acid, formaldehyde, and etc. During this process, methane gas and toxic chemicals leach out from the system and contaminate nearby groundwater. Only 30-50% of the fracturing fluid is recovered, the rest of the toxic fluid is left in the ground and is not biodegradable. This process will not safe to use for daily needs of people who live near the sites. Based on literature studies, we suggest a technology to avoid the environmental impacts called Hi-Way Flow Channel Unit (Schlumberger, 2010). This technique present the drilling on safe rate depth between 4000-6000 feet that will not contaminate groundwater aquifer. By understanding this technique, it will help to increase shale gas development in Indonesia that synergized with environment protection.

Keywords : shale gas, hydraulic fracturing, environmental impact, energy development

I. Introduction
Natural gas resources are typically divided into two categories: conventional and unconventional. Conventional gas is typically found in reservoirs with permeabilities greater than 1 millidarcy (“mD”) and can be extracted using traditional techniques. Due to its ease and low cost in extracting, conventional gas contributes the major percentage of the gas produced.
globally. In contrast, unconventional gas is found in reservoirs with relatively low permeabilities (less than 1 mD) and hence cannot be extracted via conventional methods. There are several types of unconventional gas resources that are produced today but the three most common types are tight gas, coal bed methane, and shale gas. Given the low permeability of these reservoirs, the gas must be developed via special techniques including fracture stimulation (or “fracking”) in order to be produced commercially.

A. Scientific Background

Shale Gas Characterisation

Shale gas is natural gas that is produced from a type of sedimentary rock derived from clastic sources often including mudstones or siltstones, which is known as shale. Clastic sedimentary rocks are composed of fragments (clasts) of pre-existing rocks that have been eroded, transported, deposited and lithified (hardened) into new rocks. Shales contain organic material which was lain down along with the rock fragments.

![Fig. 1 Shale Gas Occurrence](image)

In areas where conventional resource plays are located, shales can be found in the underlying rock strata and can be the source of the hydrocarbons that have migrated upwards into the reservoir rock. Shales contain organic matter (kerogen) which is the source material for all hydrocarbon resources. Over time, as the rock matures, hydrocarbons are produced from the kerogen. These may then migrate, as either a liquid or a gas, through existing fissures and fractures in the rock until they reach the earth’s surface or until they become trapped by strata of impermeable rock. Porous areas beneath these ‘traps’ collect the hydrocarbons in a conventional reservoir, frequently of sandstone.

Shale Gas development In Indonesia – Opportunities and Challenges

There are several considerable situations to determine shale gas as a new alternative energy, they are:

1) Demand for conventional oil and gas is progressively increase,

2) Abundances of shale gas associated with conventional oil and gas,
3) High demand of gas both domestically and globally must be qualified,
4) Availability of infrastructures for field development, and
5) Requirement of energy diversification, one of them is Shale Gas.

Indonesia western regions are shale gas potentials, especially the basins on the island of Sumatra, Java, and Kalimantan. The estimation of shale gas reserves have been expected at 233.05 Tcf in Sumatra, 47.64 Tcf in Java, and 193.93 Tcf in the island of Borneo. While the potential basins which have been proven to also produce conventional oil and gas are spread along northern Sumatra, central Sumatra, south Sumatra, northern west java, northern east java, Kutai basin, Barito basin, Tarakan basin, and the Bintuni Basin.
There are several challenges for shale gas development in Indonesia. However, the priority remains on studying the environmental impacts, technology and cost, as well as regulatory framework.

*Hydraulic Fracturing*

Hydraulic fracturing, or “fracking”, is the process of drilling and injecting fluid into the ground at a high pressure in order to fracture shale rocks to release natural gas inside. Shale as an unconventional resource has smaller grain size of rock matrix and poorly sorted. In this type, there are limited connected pathways that allow the hydrocarbon to flow. Hydraulic fracturing is designed to produce fracture or connect to existing fractures within the reservoir thus creating the pathway for flowing hydrocarbon to the wellbore.
Hydraulic Fracturing has several steps:

- Step 1: Press the reservoir rock using a fluid
- Step 2: Build the fracture by continuously pumping fluid to the fracture
- Step 3: Pump Proppant materials into the fracture (a slurry form)
- Step 4: Stop pumping and flowback to the well to recover the fracture fluid while leaving the proppant on reservoir

B. Scientific Problem

There are several environmental impacts associated with Hydraulic Fracturing.

**Toxic Chemicals and Radioactive Materials**

The primary environmental impacts associated with hydraulic fracturing (fracking) result from the use of toxic chemicals during the fracking process and the subsequent release of additional toxic chemicals and radioactive materials during well production. Fracking fluid flowback – the fluid pumped out of the well and separated from oil and gas, not only contains the chemical additives used in the drilling process but also contains heavy metals, radioactive materials, volatile organic compounds (VOCs) and hazardous air pollutants (HAPs) such as benzene, toluene, ethylbenzene and xylene (BTEX). Furthermore, as the image to right illustrates, numerous pathways exist throughout the fracking process for the release of these toxic and radioactive materials. As a result, the proper handling of the toxic and radioactive materials associated with frackings is essential throughout the lifecycle of a well.
Source of Water Contamination

Each gas well requires an average of 400 tanker trucks to carry water and supplies from and to the site. It takes 1-8 million gallons of water to complete each fracturing job. The water brought in is mixed with sand and chemicals to create fracking fluid. Approximately 40,000 gallons of chemicals are used per fracturing. Up to 600 chemicals are used in fracking fluid, including known carcinogens and toxins such as lead, uranium, mercury, ethylene glycol, radium, methanol, hydrochloric acid, and formaldehyde.

Gallons of water as much as 72 trillion and 360 billion gallons of chemicals needed to run the current gas wells. The mixture reaches the end of the well where the high pressure causes the nearby shale rock to crack, creating fissures where natural gas flows into the well. During this process, methane gas and toxic chemicals leach out from the system and contaminate nearby groundwater. Methane concentrations are 17 times higher in drinking-water wells near fracturing sites than in normal wells.

Contaminated well water is used for drinking water for nearby cities and towns. There have been over 1,000 documented cases of water contamination next to areas of gas drilling as well as cases of sensory, respiratory, and neurological damage due to ingested contaminated water. The waste fluid is left in open air pits to evaporate, releasing harmful VOC’s (Volatile Organic Compounds) into the atmosphere, creating contaminated air, acid rain, and ground level ozone. In the end, hydraulic fracturing produces approximately 300,000 barrels of natural gas a day, but at the price of numerous environmental, safety, and health hazards.
Air Pollution

Methane is the main component of natural gas and is twenty five times more potent in trapping heat in the atmosphere than carbon dioxide. A recent study by the National Oceanic and Atmospheric Administration (NOAA) monitoring gas wells in Weld County, Colorado, estimated that 4 percent of the methane produced by these wells is escaping into the atmosphere. NOAA scientists found the Weld County gas wells to be equal to the carbon emissions of 1-3 million cars.

A number of other air contaminants are released through the various drilling procedures, including construction and operation of the well site, transport of the materials and equipment, and disposal of the waste. Some of the pollutants released by drilling include: benzene, toluene, xylene and ethyl benzene (BTEX), particulate matter and dust, ground level ozone, or smog, nitrogen oxides, carbon monoxide, formaldehyde and metals contained in diesel fuel combustion—with exposure to these pollutants known to cause short-term illness, cancer, organ damage, nervous system disorders and birth defects or even death.
II. Aim
Energy is one of the most needed resources in every country. Until now, Indonesia is still a dependent on fossil fuel energy which cause it to always increase in demand. Nowadays, the decreasing of fossil fuel energy reserves in the world have concerned various researchers to look for alternative energy resources. Then, the presence of shale gas in the world seems to be a future potential alternative energy resources. However, it needs further studies and researches on the characteristics and all other aspects in order to take all the advantages of shale gas as a cheap and safe alternative energy sources.

III. Method
This research used integrated analysis method from several data such as literatures from geological agency and secondary data from previous researches both individuals or institutional.

IV. Analysis and Discussion
Based on the scientific problem, there are three main aspects that must be discussed to assessing shale gas development in Indonesia. Those aspects are:

- Environmental Impact
- Technology and Cost
- Regulation Framework

After doing some studies, we suggest several solutions to solve that problem.

1. Environmental Impacts
Steps that we can do for decreasing negative impact from shale gas production are as follows:
   - Reduce the emission
   - Keep people away from using surface water
   - Maintain the contamination level
   - Save depth drilling between fracking area (more than 10,000 feet)

2. Regulation Framework
To support the shale gas development in Indonesia we need to oversee the drilling and production regulation from other countries which are success to develop this energy, for example USA.

3. Technology and Cost
We suggest Hi-Way Flow Channel Fracturing as the proper method to answer difficulties in technology and cost.
**Hi-Way Channel Fracturing**

Hi-Way channel fracturing is rooted from a unique integration of placement and engineering materials, surface equipments, geomechanical modeling, fiber material expertise, and decades of fracturing experience.

Specialized completions strategies and process control equipment enable this Hi-Way technique to provide optimal recovery. The stability of the flow channels is maintained by using a proprietary fiber that protects the structure from surface to reservoir until the fracture closes and an in situ stress takes over.

The Hi-Way technique fundamentally changes the way proppant fractures generate conductivity. It decouples fracture productivity from proppant permeability and creates flow channels. Instead of following through the proppant in the pack, hydrocarbon flows through the channels, increasing conductivity by orders of magnitude.

Conductivity extends all the way to the tip of the fracture, allowing for longer effective fracture half-length, higher effective contact area, better fluid and polymer recovery, and less fracture face damage. These effects all mean optimized production and superior hydrocarbon recovery. By changing the way hydrocarbon flows, Hi-Way Channel Fracturing ensures that traditional proppant pack conductivity losses are eliminated, including crushing, fluid damage, multiphase flow, and nondarcy effects.

**Conventional Hydraulic Fracturing vs Hi-Way Channel Fracturing**

Conventional hydraulic fracturing method is applied on larger proppant sizes and resin coating to improve conductivity.

![Comparison between Conventional Fracturing and Hi-Way Channel Fracturing](image)

*Fig. 10* Comparison between Conventional Fracturing (left) and HiWAY Channel Fracturing (right).
The Hi-way service uses specialized blending equipment and control system to pump proppant in pulses – creating stable, infinite-conductivity flow channels within the fractures.

Benefits of using Hi-way Channel Fracturing on shale gas development are:
✓ The Average Hi-Way Channel Fracturing job increases production by more than 20%
✓ On Average, the Hi-Way service helps operators use 40% less proppant per job
✓ Compared to slickwater treatments, the Hi-Way service uses up to 60% less water
✓ The technique presents the drilling on safe rate depth between 4000-6000 feet that will not contaminate groundwater aquifer.

V. Conclusion and Recommendation

1. The presence of shale gas in the world is very potential that it might be the new alternative energy resources in the future. Total speculative shale gas resources in Indonesia reach up to 574.07 Tcf.
2. Environment becoming the main aspects that contaminated by hydraulic fracturing process because of its toxic and radioactive materials, source of water contamination, and air pollution.
3. We suggest some solutions that possibly could be a good way to handle the problems. Especially for environmental impact, we suggest one method, which is “Hi-Way Flow Channel Fracturing”. By understanding this technique, it will help to increase shale gas development in Indonesia that synergized with environment protection.

4. It needs further studies and researches on the characteristics of shale gas, so we can take all advantages of shale gas as a cheap and safe alternative energy sources.

**Acknowledgments**

The authors thank previous researchers and families who gave us major supports to finish this paper.

**References**


Fadhil Rianda, Andreas Franzona et al, Proceeding ICG 2016, Bandung


ICEAI-1194
Effect of Operation Condition on Moisture Removal in a Desiccant Cooling System

İrfan Uçkan\textsuperscript{a}, Tuncay Yılmaz\textsuperscript{b}, Orhan Büyükalaca\textsuperscript{b}
\textsuperscript{a}Yuzuncu Yıl University, Van, Turkey
\textsuperscript{b}Osmaniye Korkut Ata University, Osmaniye, Turkey
irfanuckan@yyu.edu.tr

Abstract
The objectives of this work are to evaluate the effect of operation condition on moisture removal of solid desiccant wheel in a novel configuration of a desiccant cooling system based and to obtain useful data and experiences for practical application. An experimental set-up was built and used to test the system performance under hot and humid real environmental conditions. System performances has evaluated in terms of moisture removal and thermal coefficient of performance COP\textsubscript{th}. Effect of different regeneration temperatures are evaluated in this system. Regeneration temperatures vary from 90°C to 110°C and volume flow rate vary from 2000 m\textsuperscript{3} to 4000 m\textsuperscript{3} under real environmental conditions. In addition, the effects of some important operating parameters, such as inlet temperature and humidity ratio of process air on the system performance has also investigated in this study.

Keywords: Evaporative cooling, moisture removal, desiccant, air conditioning.

1. Background/ Objectives and Goals
There are two types of desiccant based air conditioning systems: liquid and solid desiccant air-conditioning systems [Camargo at al., 2005; Dong at al., 2013; Gao at al., 2015] to control air humidity, especially in hot and humid areas, due to its advantage in removing the latent load from the air stream. (Liu at al. 2007).

Desiccant based air conditioning systems have been proposed as an alternative to the conventional vapor compression cooling systems. This concept is enhanced again at the present status when energy-saving and environment-preserving are two subjects in all engineering fields.

This technology, which is driven by thermal energy and uses no refrigerant, can reduce energy consumption, peak electricity demand and improve indoor air quality. It can be coupled to solar collectors to produce a cooling system with low environmental impact. Evaporative air-conditioning (EAC) technologies represent significant environmental benefits related to reducing chlorofluorocarbons (CFC) and hydrochlorofluorocarbons (HCFC) use and other
emissions. (W. Bank, 1999).

A typical desiccant-based air conditioning system or simply a desiccant-based system consists of mainly from these components such as rotary desiccant dehumidifier, heat-pipe heat exchanger, indirect/direct evaporative cooler, gas-fired heaters, fans, pumps, filters, controls and ducts [Ge et al., 2015; Alahmer 2016; Angrisani et al., 2015].

The solid rotary desiccant wheel is one of the most important component in the desiccant based air conditioning systems. The adsorption dehumidification is a physical process that fixes molecules of an adsorbate on the adsorbent surface, usually porous. Desiccants attract moisture from the air by creating an area of low vapor pressure at the surface of the desiccant. The partial pressure of the water in the air is high, so the water molecules move from the air to the desiccant and the air is dehumidified (Harriman, 1990).

Due to the complexity of the combined heat and mass transfer processes in the solid desiccant wheel, some theoretical and experimental studies carried out (Stabat, 2008; Zhang, 2002; Sphaier, 2004).

The desiccant rotary wheel provides a competitive drying facility which depends upon the hygroscopic capacity of desiccant to remove moisture from wet air. Recent research on desiccant systems has focused mainly on the development of advanced materials that can give improved moisture removal capacities [Mihajlo, 2006; Liu et al., 2003; Tokarev, 2000; Zhang, 2006].

The objective of this work is to evaluate the effect of operation condition on moisture removal of a solid desiccant wheel and investigate variation of COP\textsubscript{th} with moisture removal in a desiccant based evaporative cooling system. In the present work, the system performances were evaluated only under real summer and humid condition. Also, the effects of inlet temperature and humidity ratio of process air on dehumidification capacity and thermal coefficient of the system were examined.

2. Methods

In this work, a desiccant based evaporative air conditioning system is investigated. The moisture of the fresh air is reduced passing it through a solid desiccant wheel and then its temperature is decreased by the evaporative cooling unit. To enhance the performance of the system, some technologies such as pre-cooling with outdoor air, waste cool recovery and pre-cooling of waste air by evaporative cooling are evaluated on the system.

There are three main air channels in this experimental system. Regeneration air taken from
outdoor air and a rotary regenerator heat exchanger is used for heat recovery in regeneration air channel. Upon these improvements, the evaporative cooling units, heat exchangers and the coefficient of performance of the system are investigated to investigate the applicability of this system shown in Figure 1.

This desiccant based evaporative cooling system consists mainly from the following components: 1 rotary desiccant dehumidifier, 3 heat exchangers, 2 direct evaporative coolers, 1 heater, 3 fans (used for fresh air, regeneration air and waste air), 2 pumps (used for direct evaporative coolers), filters, control units and ducts. This system, as can be seen from the Figure 1, has three main air channels.

![Figure 1. General view of investigated experimental system.](image)

The first channel is used to take fresh air from outdoor and blow it into the air-conditioned room. The exhaust air is discharged from the room by a fan in the second channel. Third channel is used for regeneration air stream. The air flow rates are controlled by a control unit. At the inlet of the fresh air channel and regeneration air channel, there is a filter respectively. The dehumidifier section is followed by the heat exchanger 1 and heat exchanger 2 to pre-cool the fresh air. After the heat exchanger 2, there is an evaporative cooler to cool the fresh air to the blowing temperature.

In this system rotary desiccant dehumidifier removes moisture from the fresh air (process 2–3). The dry fresh air is cooled first by the regeneration air in the heat exchanger 1 (process 3–4). In the second step, the fresh air is entering into the heat exchanger 2 (process 4–5) where fresh air is cooled again by exhaust air. After these processes, fresh air is entering into the evaporative cooler 1 (process 5–6) where last cooling process occurs. The fresh air cooled in these processes is supplied into the air conditioning room (state 6). Waste air first passes through the
evaporative cooler 2 (process 7–8), then it enters the heat exchanger 2 (process 8-9). As the waste air passes through the heat exchanger 2 its temperature is increasing but temperature of the fresh air is decreasing at the same time. After that, air is discharged to atmosphere.

a. **Experimental conditions**

The results obtained from the experiments during the cooling season were evaluated the effect of operation condition on the moisture removal of a desiccant based evaporative air conditioning system. Different experiments were carried out on the system. In the experiments, flow rate of the air streams (fresh, waste and regeneration) were kept constant volume flow rate with a value of 2000 m$^3$/h, 3000 m$^3$/h and 4000 m$^3$/h. The ratio of volume flow rate for all air streams is 1 for all experiments. Temperature of regeneration air was adjusted to 90 °C, 100 °C and 110 °C for every flow rate.

b. **Performance indexes**

In this paper, the performances of the silica gel desiccant wheel are evaluated based on two different criteria: (1) moisture removal capacity and (2) thermal coefficient of performance. The cooling capacity of the system is expressed by:

$$\dot{Q}_{ce} = m_f (h_1 - h_g)$$

and regeneration heat is calculated by:

$$\dot{Q}_{reg} = m_r c_p (T_{14} - T_{13})$$

Total energy consumption of the system is expressed by:

$$\dot{W}_{Total} = \dot{Q}_{reg} + \dot{W}_{fan} + \dot{W}_{oth}$$

The COP$^\text{th}$ of the system is defined as the ratio of the cooling capacity to the total energy input to the system. Then the COP of this system is expressed by [Heiderinejat, 2010]:

$$\text{COP}_{th} = \frac{\dot{Q}_{ce}}{\dot{W}_{Total}}$$

Moisture removal capacity is an operating parameter for desiccant wheel. The absolute humidity difference between regeneration side and process side for desiccant wheel is expressed by the following equations:

for the process side

$$\Delta W_f = w_i - w_j$$

and for the regeneration side

$$\Delta W_r = w_{i5} - w_{i4}$$

3. **Results**
Effect of daily average ambient air relative humidity ($\varphi_{\text{ambient}}$) on daily total moisture removal ($\Delta W_{\text{removal}}$) for different regeneration temperature set values and different flow rate (2000 m$^3$/h, 3000 m$^3$/h and 4000 m$^3$/h) that is equal for all air streams is shown in Figures 2-4. In these experiments, the average relative humidity of ambient air during the day varies between %41 and %60. As seen from figures, amount of daily total moisture removal increases with the increasing of relative humidity and from these figures the daily total moisture removal increases with the increase of regeneration temperature. This is due to high humidity results that have large potential for moisture transfer, which provides more moisture removal capacity. Also; it is observed from these figures that daily total moisture removal at the same regeneration temperature decrease when flow rate of air increases. Based on these figures daily total maximum absolute humidity removal is obtained at maximum ambient air relative humidity and maximum regeneration temperature with flow rate of 4000 m$^3$/h.
Figure 5 shows the effect of different regeneration temperature on daily total moisture removal for different flow rate from 2000 m$^3$/h to 4000 m$^3$/h. As seen from this figure, the daily total moisture removal increases with the increase of regeneration temperature from 90 °C to 110 °C. It is expected result because increasing of the regeneration temperature removes more moisture from desiccant wheel. But the effect of flow rate shows the opposite effect on the moisture removal. As flow rate of air increases, the moisture removal decreases for all regeneration temperature. As illustrated in Fig.5, the most moisture removal occurs in high regeneration temperature and low volume flow rate110 °C and 2000m$^3$/h respectively, which are optimum parameters for moisture removal in this system. Based on this operation condition daily total maximum and minimum moisture removal occurs at 110 °C and 90 °C with 5564 g/kg and 10473 g/kg, respectively.

In actual situations, inlet conditions of the system such as ambient air temperature as well as humidity ratio of the process and the regeneration air vary in different weather conditions and application areas. Therefore, it is useful to investigate the influences of these parameters on the system performance. The data measured during the day are evaluated based on the COP$_{th}$ and moisture removal illustrated on Fig. 6. In this figure, it is observed that moisture removal remains approximately constant with 6 g/kg during the day. But the COP$_{th}$ increases towards midday. The reason of this effect is due to increasing of ambient air temperature towards midday. Because increasing of ambient air temperature reduce the energy needs for regeneration air process.
The variations of moisture removal as a function of the air flow rate are shown in Fig.7. The figure shows the effect of flow rate of process air on moisture removal of desiccant wheel. It is observed that there is about 40% decrease of moisture removal when volume flow rate of process air increases from 2000 m³/h to 4000 m³/h. On the contrary, COPₜh decrease to about 15% at the same condition. On the other hand the thermal energy needed by regeneration air is not fixed, and then COPₜh decrease. When the flow rate of process air is increased between 2000 m³/h to 4000 m³/h, then the COPₜh is decreased to 0.6 to 0.5. This effect is due to fixed
regeneration temperature. When volume flow rate of air increased to achieve a constant regeneration temperature, then more energy is required. So, COP_{th} decreases due to this effect.

4. Conclusion

- The amount of daily total moisture removal increases with the increasing of relative humidity and regeneration temperature. Also; it is observed that daily total moisture removal at the same regeneration temperature increases when flow rate of air increases. Daily total maximum moisture removal is obtained at maximum ambient air relative humidity and maximum regeneration temperature with flow rate of 4000 m^3/h.

- Flow rate has a considerably effect on daily total moisture removal for different regeneration temperature. When flow rate of air increases at the same regeneration temperature, the daily total moisture removal increases also.

- The effects of different flow rate on daily average COP_{th} and on daily average moisture removal have been investigated. It is observed that daily COP_{th} of the system decreases with the decreasing of moisture removal. It is also seen that as flow rate of air increases, daily average COP_{th} increases.

5. References

Ventilated Truncated Tabs for the Passive Control of Supersonic Elliptic Jets

Saif Akram\textsuperscript{a*}, E. Rathakrishnan\textsuperscript{b}

\textsuperscript{a} Ph.D. Student, Deptt. of Aerospace Engg., Indian Institute of Technology, Kanpur, India
\textsuperscript{b} Professor, Department of Aerospace Engg., Indian Institute of Technology, Kanpur, India
sakram@iitk.ac.in

Abstract

A tremendous amount of researches have been conducted recently on the effect of tabs, which are small protrusions into the flow exiting a jet nozzle, on the subsequent evolution and mixing of free jets. These studies are motivated by the technological need to increase mixing and reduce noise, especially in high-speed jets. Since most of the previous studies dealt primarily with unventilated tabs placed right at the nozzle exit, the effect of ventilation of the tabs, keeping the blockage area constant, is examined experimentally in the present investigation.

The experimental model used in the present investigation is a Mach 1.5 convergent-divergent elliptic nozzle with an aspect ratio of 3:1 and made of brass. The equivalent throat and exit diameters of the nozzle are 10 mm and 11.48 mm respectively. The critical and correctly expanded pressure ratios are 1.89 and 3.67 respectively. The mixing promoting capability of unventilated and ventilated truncated vertex triangular tabs is investigated at the NPRs 3, 4, 5, 6, 7 and 8. NPR 3 is in over expanded state with an overexpansion level of 18.27% at nozzle exit. NPR 4, 5, 6 are in moderate under-expansion state with under-expansion levels of 8.99%, 36.24%, and 63.49% respectively. NPR 7 and 8 are the cases of highly underexpanded jets with under-expansion levels of 90.7% and 117.9% respectively. The performance of controlled jets are compared with uncontrolled jets for all the NPRs.

Cursory observations during the course of the present study revealed that the ventilation of the truncated tab does result in a slight mixing enhancement in case of overexpanded condition whereas in all the cases of underexpanded conditions, no significant alteration in the flowfield is found. The CPD plots at NPR 3, which is the case of overexpanded jet, clearly shows that there is a core length reduction of 82.7 percent when ventilated tabs are applied to minor axis as compared to 69.1 percent for the unventilated tabs. For the cases of marginally underexpanded (NPR 4), moderately underexpanded (NPR 5 and NPR 6) and highly underexpanded (NPR 7 and NPR 8) jets, the CPD plots for unventilated and ventilated tabs almost coincide. This means that the core length reductions and hence the mixing enhancement by both types of tabs are similar in underexpanded states.
Keywords: Ventilated Tabs, Elliptic Jet, Supersonic Flow
ICEAI-1079
Experimental Study of The Evaporation Characteristics of A Binary Fuel Droplet in Rapid Compression Machine Conditions

Jong Han Won*, Seung Wook Baek, Hyemin Kim and Hyeongjin Ahn
Department of Aerospace Engineering, Korea Advanced Institute of Science and Technology, South Korea
*won1402@kaist.ac.kr

Abstract
In this study, the evaporation characteristics of a single droplet of binary fuel were experimentally investigated for unsteady pressure and temperature variation inside rapid compression machine (RCM). RCM simulates a single compression stroke in homogeneous compression charge ignition (HCCI) environment under unsteady condition. As the binary fuel, n-heptane and n-decane were used for three volumetric ratios of 25:75%, 50:50%, and 75:25% respectively. A droplet was suspended on a fine tip of thermocouple located at a center of the reaction chamber filled in N₂ gas, while inner temperature of a droplet was measured. The experimental results showed that a single droplet including more n-heptane resulted in a lower initial temperature before reaching the boiling point and a faster evaporation. However, the maximum temperature was lower due to higher heat of vaporization of n-heptane.

Keywords: Droplet, RCM, Binary fuel, Evaporation, Unsteady condition

1. Background/ Objectives and Goals
Recently, combustion efficiency as well as emission reduction of the internal combustion engine is one of the main issues for engine development. Application of new technology to conventional engine such as gasoline direct injection (GDI) and homogeneous charge compression ignition (HCCI) has been developed in past decades. Specifically, HCCI technology has been spotlighted as an innovative method in achieving higher engine efficiency while reducing the Particulate Matter (PM) and Nitrogen Oxide (NOx) simultaneously. Nevertheless, it is known that combustion control of HCCI engine is one of the main challenges since it does not have any ignitor.

When the liquid fuel is injected into the combustion chamber of HCCI engine, fuel is atomized in forms of droplets. As the compression stroke proceeds, the temperature and pressure conditions around the dispersed droplets are temporally varied. In this circumstance, evaporation characteristics of droplet are quite important factor. Moreover, the evaporation of multicomponent fuel droplet showed distinctive behavior due to the different evaporation rate of each fuel component. Considering that usual gasoline and diesel are composed of several
fuel components, an observation of binary/multicomponent fuel evaporation may provide the basic understanding for spray evaporation.

Many researchers have studied the evaporation characteristic of a binary/multicomponent fuel droplet in various conditions. Ghassemi et al. experimentally studied it at the different environmental conditions under normal gravity. Heptane and hexadecane were used as the binary fuel with different evaporation rates and boiling temperatures. They found that the evaporation of the binary fuel droplet accompanied a bubble formation at low pressure and led to incomplete micro-explosion. But the bubble formation disappeared at higher pressure environment.

Sazhin et al. researched the evaporation study of multi-component droplet and compared experiment data with numerical simulation. In this study, n-decane/3-pentanone mixture was used as the binary fuel at atmosphere pressure and uniformly preheated temperature. A decrease in droplet radius was observed temporally and the prediction of numerical simulation was in a good agreement with experimental study.

Stengele et al. studied experimental and theoretical droplet vaporization of bi-component at high pressure and temperature atmosphere. The droplet was evaporated during free falling, while non-interacting droplets were investigated. Ambient gas was nitrogen and fuel was mixed with n-pentane and n-nonane. At the same temperature, a single droplet evaporated faster for higher pressure. At the same pressure, the decreasing rate in droplet size increased with higher temperature.

Most of studies above are conducted in uniform temperature and pressure conditions due to the limitation of experiment set up. It is different from the real situation of droplet evaporation in internal combustion engine, because the temperature and pressure conditions are temporally changed. Kim et al. conducted experimental research to observe the evaporation characteristic of a single n-heptane droplet in transient ambient condition by using rapid compression machine. The goal of this study is to apply binary component fuel, and to observe the evaporation characteristics in RCM conditions. This may improve the understandings of transient behavior of binary component fuel droplet.

In this study, evaporation characteristics of binary fuel of n-heptane and n-decane were experimentally studied in various mixing ratios in RCM conditions.

2. Methods

2.1 Experimental Apparatus
The design inside rapid compression machine is shown in Fig.1. RCM consists of a reaction
chamber, forward driving chamber and backward driving chamber of a piston. As moving the adjust wheel at backward driving chamber, RCM can change the operating time during a compression stroke from the end to the top dead center (TDC). The each driving chamber is pressurized different pressure using dry air. The forward driving chamber and backward driving chamber set to 14 bar and 12 bar respectively so a piston can be fixed at the end. As removing dry air at forward driving chamber, a piston goes to the left side. A piston is decelerated when finishing a compression stroke as the clearance at forward driving chamber. It prevents from rebound a piston that acts as buffers between a piston and the wall of reaction chamber.

Fig. 2 is the schematic of the experimental apparatus. After a piston fixed at the end, a droplet was suspended from syringe at the tip of thermocouple and then syringe was eliminated for sealing the reaction chamber of N₂ atmosphere. Heating jacket was used to uniformly maintain room temperature at 25 ℃ in the reaction chamber. As soon as opening the solenoid valve, dry air in forward driving chamber came out and simultaneously a compression stroke started. The pressure in the reaction chamber was elevated about 30 bar and it was observed by a pressure transducer. The pressure transducer is Snys PMS model that has excellent durability for an instant pressure shock and thermal effect. The thermocouple as K-type was removed the cover near the tip and its bead was welded by Cr-Al wires. The diameter of a wire was 50 μm and the diameter of a bead was lower than 100 μm. Pressure transducer and thermocouple were installed as shown the cross section of the reaction chamber in Fig.2. A bead of thermocouple was located in middle of the reaction chamber to eliminate the boundary effect. Thermocouple would have some errors because heat capacity of metal wires caused heat loss inside a droplet. For compensating heat loss, Park et al. studied the measurement error of thermocouple suspended a droplet at the bead. In this study, 50 μm wire of thermocouple had an error less than 10 % and it could be reduced using compensated equation. As using the compensation, the measurement error was reduced. High speed CCD camera captured reducing process of a droplet using 500 frame rates per 2 seconds through the quartz window from the side. The data came into a personal computer (PC) and then went through post-processing.
The fuels used in experiment were n-heptane and n-decane as three volumetric ratios for exactly investigating on effect of each fuel. The volumetric concentration of n-heptane and n-decane were set to 25:75%, 50:50%, and 75:25% respectively. The thermophysical properties of fuels from KDB (Korea Thermophysical Properties Data Bank) are listed in Table 1.

### Table 1: Thermophysical properties of n-heptane and n-decane

<table>
<thead>
<tr>
<th>Property</th>
<th>n-heptane</th>
<th>n-decane</th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (g/mL)</td>
<td>0.680</td>
<td>0.730</td>
</tr>
<tr>
<td>Boiling point (°C)</td>
<td>98</td>
<td>174</td>
</tr>
<tr>
<td>Specific heat (kJ/L*K)</td>
<td>1.52</td>
<td>1.62</td>
</tr>
<tr>
<td>Heat of vaporization (kJ/L)</td>
<td>215.11</td>
<td>201.52</td>
</tr>
<tr>
<td>Vapor pressure (Pa at 25 °C)</td>
<td>6076</td>
<td>191</td>
</tr>
</tbody>
</table>

#### 2.2 Binary fuel

The fuels used in experiment were n-heptane and n-decane as three volumetric ratios for exactly investigating on effect of each fuel. The volumetric concentration of n-heptane and n-decane were set to 25:75%, 50:50%, and 75:25% respectively. The thermophysical properties of fuels from KDB (Korea Thermophysical Properties Data Bank) are listed in Table 1.

### 3. Results

#### 3.1 Experimental conditions

The experimental study on evaporation characteristics of a binary fuel droplet was carried out
in the diameter range of 450 to 650 µm. For investigating the effect of various concentrations of n-heptane and n-decane, experimental conditions were set to an operation time at 205 ms ± 10, initial temperature at 25 °C ± 1, and compression ratio at 18.

3.2 Droplet evaporation

The temperature inside the reaction chamber could be calculated by adiabatic core hypothesis (equation 1) which assumed uniform temperature for core of the reaction chamber except for boundary layer near the wall. It was usually used in previous researches on RCM to estimate the core temperature of the reaction chamber. Figure 3 shows a variation of core gas temperature and boiling temperatures of n-heptane and n-decane along the time. The core temperature increased up to 450 °C at TDC (205 ms) while exceeding the boiling temperature of n-heptane at 61 ms and n-decane at 115 ms. After TDC, the core temperature and boiling temperature slowly decreased because of heat loss to the wall.

\[
\int_{T_0}^{T(t)} \frac{\gamma}{\gamma - 1} \frac{dT}{T} = \ln \frac{P(t)}{P_0} \tag{1}
\]

Figure 4 shows variations of the droplet diameter squared with different mixing ratios along the time. The initial diameter of a droplet in three cases was about 560 µm. Until TDC, a droplet was thermally expanded because of sharply increasing temperature and pressure inside the reaction chamber. The thermal expansion happened when the amount of evaporation was relatively lower than reduced density resulted from increasing gas temperature. After that, blue one including 75 % of n-heptane starts to sharply decrease than the other ones because n-heptane, which has a lower boiling temperature than n-decane, is easy to vaporize so the droplet size decreased faster. After 300 ms, the slope of blue and red ones, which means the evaporation rate of a droplet, had an inflection point, however not for black one with 25 % of n-heptane. The occurrence of an inflection was caused by different evaporation rate of n-heptane and n-decane. After most of n-heptane is vaporized, n-decane is dominantly left in a droplet, of which evaporation rate is lower than that of n-heptane. But most of n-heptane for black one was evaporated before TDC so that there was no change in the slope due to dominantly remaining n-decane after TDC. Since then, the slope slowly decreased due to heat loss the chamber wall.

The temporal temperature variations inside a droplet are shown in Fig.5 for the droplets with different mixing ratios. The initial droplet temperature before reaching the boiling point was lower as more n-heptane was included. It resulted from lower wet bulb temperature because n-heptane was easier to vaporize than n-decane before reaching the boiling point due to higher vapor pressure and low boiling point. Just before TDC, a rapid increase in the temperature and pressure in the reaction chamber resulted in faster droplet heat-up. A lower specific heat of n-heptane incurs faster droplet heat-up so that the slope of blue one showed a faster increase.
As the droplet evaporation proceeds after TDC, the heat feedback to a droplet was mainly used for evaporation. Since the heat of vaporization of n-heptane was higher than that of n-decane, the droplet temperature including more n-heptane increased slowly, reaching a lower maximum temperature. After reaching a maximum temperature, it slowly decreased due to heat loss to the wall.

Fig. 3: Variation of boiling temperature along time

Fig. 4: Variation of droplet size squared along time
3.3 Acknowledgment

This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MEST) (No. 2014R1A2A2A01007347).

4. References


Environmental Sciences (3)/ Civil Engineering (2)

Wednesday, May 11, 2016 13:00-14:30 Room 1006

Session Chair: Prof. Murad Helaleh

ICCBES-1243
Determination of Polybrominated Diphenly Ethers in Human Adipose Tissue by Selective Reaction Monitoring Triple Quad Gas Chromatography MS_MS
Murad Helaleh | Anti Doping Lab
Nada Al Tamimi | Anti Doping Lab
Noof Al Qasmi | Anti Doping Lab
Aishah Latiff | Anti Doping Lab
Mohamed Al Rayes | Anti Doping Lab
Thomas Michael Harvey | Anti Doping Lab

ICCBES-1252
Estimation of Greenhouse Gas Emissions from a Wastewater Treatment Plant with Membrane Bioreactor Technology
Ying-Chu Chen | National Taipei University

ICCBES-1269
Management of Water Quality in a Semi-Enclosed Marine Bay – Insights from Biomanipulation
Chong Kim Wong | The Chinese University of Hong Kong

ICEAI-1024
The Using of Ground Screw Pile as Mounting Structure Foundation in Solar PV Farm
Attasit Sirivachiraporn | Srinakharinwirot University
Chaisiri Wattanachannarong | Future Electrical Control Company Limited

ICEAI-1190
Wastewater Containing Chromium (Cr) Management Using Water Cabbage (Pistia Stratiotes) as Bioremediator in Different Size and Exposure Time
Umi Zakiyah | Brawijaya University
Indah Wahyu Rahmawati | Brawijaya University
High-Temperature Corrosion of T22 Steel in N₂/H₂S-Mixed Gas

Min Jung Kim | Sungkyunkwan University
Dong Bok Lee | Sungkyunkwan University
Determination of Polybrominated Diphenyl Ethers in Human Adipose Tissue by Selective Reaction Monitoring Triple Quad Gas Chromatography MS MS

Murad Helaleh*a, Nada Al-Tamimi*a, Noof Al_Qasmi*a, Aishah Latiff*a, Mohamed El-Rayes*b, Thomas M.H*c

*a Anti Doping Lab, Toxicology and Multi-purpose Lab., P.O Box: 27775, Doha, Qatar
*b Anti Doping Lab, Risk Quality, P.O Box: 27775, Doha, Qatar
*c Anti Doping Lab, life Science, P.O Box: 27775, Doha, Qatar

*mhelaleh@adlqatar.qa

1. Background/ Objectives and Goals
Polybrominated diphenyl ethers (PBDEs) are a class of brominated flame retardants (BFR), accounting for 33% of the worldwide BFR production in 2001. They are listed as priority substances within the European Union Water Framework Directive, and their occurrence in the environment has been a cause of growing concern. PBDEs have been widely used as flame retardants and was used in polyurethane, foams, computers, paint and plastic to reduce fire risk. PBDEs are tend to bio-accumulate through the food chain. Several studies have reported the occurrence of these chemicals in environmental and human body fat. Detection levels of PBDEs in human is important in order to estimate exposure to these chemicals. Monitoring of PBDEs in humans has been started only recently and no date available from Qatar population. However, PBDEs levels in humans are on the order of nano-gram per gram of lipid weight. Most of the work has been carried out by sensitive systems, such as electron impact selective reaction monitoring mass spectrometry (EI_SRM), were mass of the molecular ion and product ion for each level of brominated is recorded. The advantage of electron ionization mode is to reduce the miss-interpretations of interfering substances and allows the use of 13C-labeled standards (as internal standards) which resulted in obtaining more quantification accurate results. In this context, an analytical method was developed for the simultaneous measurement of tri- to decaBDE from adipose human tissue. Therefore, our primary objectives were: (1) to analyze human adipose tissue specimens from Qatar population, and (2) to explore levels of PBDEs in order to understand the pattern of exposure.

2. Methods

a. Extraction procedure:
Before sample extraction, the internal standards (including 13C-PBDEs) were added into the adipose tissue. Adipose tissue sample was homogenized with anhydrous sodium sulfate/diatomaceous earth. Aliquot of the extract was evaporated and the residues were weighted for lipid determination. Place the cells filled with the adipose tissue sample and acidic silica
(40%) onto the ASE300. Label the appropriate numbers of collection vials and place these into the vial carousel. Set up the extraction method and begin the extraction. Using the following extraction conditions: Solvent: hexane: DCM (9:1); temperature= 80 °C; pressure= 1500 psi; static time= 5 min; static cycles= 2; flush= 60% and purge= 240 s.

b. **GC-MS conditions:**
The quantification of PBDEs was performed using thermo_TSQ, in an electron ionization (EI) mode with MS-MS. The separation procedure and the monitored ion fragments of all BDE congeners has been achieved by fragment the parent ions and quantified using two parent ions and two daughter ion. For BDE-209 are performed using 15 m column, with a DB-5 column (15 m × 0.25 mm internal diameter and 0.25 μm film thickness). The GC oven temperature was programmed as follows: the initial temperature of 120°C was maintained for 2 min, which was then increased to 250°C at a rate of 25°C min⁻¹, followed by a 15.0 °C min⁻¹ increase to 260°C and finally at 25.0 °C min⁻¹ increase to 300°C for 15 min. The GC was equipped with a programmed temperature vaporization (PTV) injector run in the split-less mode, which was set at 80°C with a split-flow of 100 ml/min and a split-less time of 1.5 min. The flow rate was 1.2 ml/min with helium as carrier gas.

3. **Expected Results/ Conclusion/ Contribution**
The method allows the determination of PBDEs congeners from mono_PBDEs to deca_PBDEs. The five major PBDE congeners (BDE 28, 47, 99, 100, and 153) at concentrations below 1 ng/g lipid weight was achieved.

Among the 28 PBDEs profile, seventeen PBDE congeners were identified (BDEs 28, 66, 71, 77, 100, 119, 85, 155, 154, 153, 138, 166, 183, 181, 191, 205 and 207). BDE-66 was found to be the dominated congener, followed by BDEs 181, 191, 183, and 138. BDEs 153, 154, 166, 205 and 207 were also detected in most human adipose tissue samples. Total PBDEs concentration (as a sum of all counted congeners) were ranged from 0.18 to 22.94 ng/g lipid weight. Tri- to hepta-BDEs in adipose tissue, the major BDEs congeners monitored (BDEs 28, 66, 71, 77, 100, 119, 85, 155, 154, 153, 138 and 183) were identified in most of the analyzed samples. The total concentration calculated for these congeners ranged from 0.18 to 11.90 ng/g lw. However, for the octa- to deca-PBDEs in adipose tissue, BDE-205 and BDE-207 could be quantified in the analyzed samples, at concentration levels 0.66 ng/g lw and 0.43 ng/g lw. The results clearly demonstrate the presence of high molecular weight PBDEs in human adipose tissue. This suggest to conduct a further investigation to carry on related to these substances in order to understand the extend of occurrence in adipose tissue and how they represent a toxicological hazard for human health. The results clearly show the ubiquitous occurrence of PBDEs in the tested samples from Qatar.
This is the first study to report levels of PBDEs in human adipose tissue from Qatar. The results should treat with caution, as they are based on a small sample size. Levels of PBDEs in more than 20 Qatari human adipose tissue samples were analyzed and the results were compared with the values from Europe and rest of the words.

Keywords: PBDEs monitoring, human adipose tissue sample; GC-EI-SRM
Estimation of Greenhouse Gas Emissions from a Wastewater Treatment Plant with Membrane Bioreactor Technology

Ying-Chu Chen
Institute of Natural Resources Management, National Taipei University, Taiwan
ycchen@mail.ntpu.edu.tw

1. Introduction
Global climate change caused by greenhouse gas (GHG) emissions has drawn the worldwide attention. Accumulation of emitted GHGs has increased rapidly and threatened the environment (Kyung et al., 2015). Wastewater treatment plants (WWTPs) have been identified as one of the significant GHG sources (Corominas et al., 2012; Sahely et al., 2006; Yerushalmi et al., 2013). The WWTPs will be soon confronted with challenges of GHG mitigations and maintenance of water quality standards. Therefore, potential of GHG emissions from WWTPs should be accurately estimated to effective manage their GHG mitigation strategies.

Due to limited water resources in Taiwan, the Taiwanese government is keenly aware in sustainable development of water resources. Development of WWTPs can be one practical approach to solve both water pollution and limited water resources. The MBR technology is frequently applied to small-sale WWTPs due to its less land space requirement and adoption on high mixed liquor suspended solids (MLSS). Accordingly, the small-scale WWTPs with MBR technology on campus can be an indicator to estimate their GHG emissions and possible GHG mitigations for better protection of water resources.

This research aims to establish a reliable technique to quantify GHG emissions from the WWTP with MBR technology. Impacts of both on-site and off-site sources of GHG emissions were all investigated. This research is expected to be of interest to a wide range of professionals, including policy makers, WWTP managers and operators, water authorities and researchers to establish sustainable management of WWTPs.

2. Methods
The experiment was conducted from Jun 2011 to Jun 2015 at the WWTP located on campus in the Northwestern Taiwan. The adopted MBR technology in the WWTP consists (1) a grit chamber to remove grit from wastewater streams, (2) an equalization reactor to adjust pH value and volume of wastewater treated, (3) a primary clarifier to settle (suspended) solids, (4) an aerobic MBR technology, and (5) a sludge treatment (Fig. 1).

2.1. On-site GHG emissions
Due to lack of researches on GHG emission factors or parameters from the WWTPs in Taiwan, this study generally used default values suggested by the IPCC (2006). Both CH$_4$ and N$_2$O emissions were converted to CO$_2$-equivalent (CO$_2$-eq) emissions by multiplying their GWPs, and then added to estimate total on-site GHG emissions.

$$\text{GHG}_{\text{on-site}} = \text{GHG}_{\text{CH}_4} \times 25 + \text{GHG}_{\text{N}_2\text{O}} \times 298$$

2.2. Off-site GHG emissions

Off-site GHG emissions are stemmed from electricity production as well as chemicals addition during wastewater treatment. Total off-site GHG emissions were calculated as follows:

$$\text{GHG}_{\text{off-site}} = \text{GHG}_{\text{electricity}} + \text{GHG}_{\text{chemical}}$$

3. Expected Results

This study estimated both on-site and off-site GHG emissions from the WWTP with MBR technology using a simple and reliable approach and determined the main sources of on-site and off-site GHG emissions. Suitable tactics to GHG mitigations were also suggested. Total GHG emissions were related to electricity consumption, followed by chemicals addition, and on-site GHGs in this study. Substantial amounts of off-site GHG emissions were generated by the electricity consumption and chemicals production. The approach developed in this study cannot estimate GHG emissions from each operating units at this stage but gave a brief knowledge on potential of GHG emissions from the WWTP with MBR technology. Furthermore, the results of this research could lead to development of novel green and sustainable wastewater treatment technology maintaining water quality standards, as well as lower GHG emissions in the near future.

Keyword: Greenhouse gas; membrane bioreactor; Taiwan; Wastewater treatment plant

![Fig.1. The system boundary of the WWTP with SBR process.](image)
Trophic cascade occurs in freshwater lakes when a decline in the number of fish-eating (piscivorous) fish results in an increase in zooplankton-eating (zooplanktivorous) fish, a decrease in the density of zooplankton herbivores, and an abundance of algae. Biomanipulation, involving the removal of zooplanktivorous fish by fishing or by the introduction of piscivorous fish, has been used successfully to control algal blooms induced by eutrophication in many freshwater lakes. Tolo Harbour is a small, shallow bay in the northeastern corner of Hong Kong. Similar to freshwater lakes, it is semi-closed and contains a relatively simple and small pelagic community. During the 1980s, excessive nutrient loading from an increasing human population led to a dramatic increase in nutrient concentrations, which in turn caused noticeable increases in algal biomass and algal bloom occurrences. An action plan to reduce nutrient loading was launched in 1980s and became fully operational in 1998. Two decades of nutrient reduction has led to noticeable changes in the plankton community and the dynamics of the planktonic food web in Tolo Harbour. A marked decrease in the number of algal blooms was documented, but the decline of large dinoflagellates was accompanied by an increase in the abundance of diatoms and small flagellates. Chlorophyll-α concentrations have remained relatively high, and the failure of Tolo Harbour to return to a clear-water state is confirmed by a lack of improvement in turbidity and water transparency. Decades of intense fishing pressure have resulted in the disappearance of large piscivorous fish (eg. groupers and seabreams) in Tolo Harbour. Increase in the abundance of zooplanktivores can be inferred by a decrease in the density of copepods, the major zooplankton herbivores, and a shift of the copepods community to small bodied species. Studies of freshwater lakes suggest that manipulation of piscivores by reducing fish pressure can cause a concomitant decrease in zooplanktivore abundance, resulting in increased in the density of zooplankton herbivores, and ultimate decrease in algal biomass. Lower algal biomass and higher transparency favor the re-establishment of macrophytes, and further enhance the effectiveness of nutrient reduction.

Keywords: phytoplankton, zooplankton, fish, water quality, biomanipulation
The Using of Ground Screw Pile as Mounting Structure Foundation in Solar PV Farm

Sirivachiraporn, A.*a, Wattanachannarong, C. b

*aDepartment of Civil Engineering, Srinakarinwirot University, Rang sit - Nakorn Nayok Road, Nakorn Nayok, Thailand
bFuture Electrical Control Co.,Ltd., Ruam Jit Road, Dusit, Bangkok, Thailand
*attasit@swu.ac.th

Abstract

Thailand alternative energy consumption has increased continuously, due to the policy of alternative energy development is targeted to up more alternative energy consumption in all sectors, especially alternative energy which can be produced in the country for example solar energy. In 2014, the total installed capacity of electricity generation by using solar PV was 1,298.51 MW, up 57.7% from the previous year and substantially increased in the last 10 years (Dept. of Alternative Energy Development and Efficiency of Thailand). Most of solar farm projects were solar ground type while PVs were installed on steel mounting structure. Ground screw steel pile (helical pile) was applied for foundation because the convenient of installation and fasten with PV mounting frame. The ground screw load test was performed to prove the axial pile capacity for the advantage of engineering design for PV mounting structure. The compression test method was conformed to the ASTM D1143-81 and ASTM D3689-83 for pull-out test method. The loading sequence and the maintaining period of different load increments were carried out and the pile head movement also monitored. From the test results reveal that the ground screw pile capacity can support and maintain the compression and pull-out load be between 1,000 to 2,000 kg depend on the pile length and subsoil condition in each location. The displacements of pile in load direction were observed which less than 15% of ground screw diameter.

Keyword: Pile load test, Ground screw pile, Solar PV mounting structure

1. Introduction

Recent high fuel oil crisis has brought closer attention to Thai authority for all possible alternative energy sources. It has been set as a National Agenda for the action plan in promoting renewable energy. And solar energy is one of the major sources of energy that has been mentioned in the strategic development plan as a sustainable renewable energy. Solar cells or photovoltaic cells are in fact large area semiconductor diodes that convert sunlight into electrical current to produce usable power. The total installed capacity of electricity generation
by using solar PV was 1,298.51 MW in 2014, up 57.7% from 2013 and substantially increased in the last 10 years as shown in Table 1 (Department of Alternative Energy Development and Efficiency of Thailand, DEDE).

<table>
<thead>
<tr>
<th>Solar PV installed capacity (MW)</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>48.6</td>
<td>78.7</td>
<td>376.7</td>
<td>823.5</td>
<td>1298.5</td>
</tr>
</tbody>
</table>

2. Solar PV mounting structure

The PV panels were mounted on steel frame and installed into ground with steel screw pile as shown in Figure 1. All steel structural members, bolts and nuts were protected by hot dip galvanized after fabrication in accordance with ASTM standard.

The frame load carrying capacity is verified by Working Stress Design according to Thailand Standard which based on AISC standard. Loads are comprised of dead loads, live loads and wind loads. Dead loads are weight of PV panels, steel frames, purlins and piles. Walking on PV panel is prohibited and there are not such activities working directly on the panels, so, no live loads are considered. Wind loads depend on location of terrain (flat area or wind obstacle), height of frame, opening and slope of structure. Purlin span length is varied between 2.80m – 3.00m depend on arrangement of frame. From load cases combination, compressive load on one pile is between 400 - 600 kg and tension load (pull-out) is between 600 - 900 kg. The foundation of steel frame used ground screw steel pile which manufactured by steel tube with diameter 76 mm and welded with 10 mm width spiral steel plate along the pile shaft as shown in Figure 2. The advantage of this foundation type is installation time by piling machine and fast assembly with upper part of steel frame. The piling installation machine is based on excavator chassis with small track equipped with pile guide and rotation
device with pile connecting for rotate and push the screw pile into precise location as shown in Figure 3.

![Figure 2 drawing of ground screw pile](image)

3. Ground screw pile testing

The verification of pile capacity was performed by pile load testing both of pile compression test and pile tension (pull-out) test by loaded to 200% of maximum calculation load. The pile compression testing was followed ASTM D 1143-81 “Standard Test Method for Piles Under Static Axial Compression Load”[2] while pull-out testing followed D 3689-90 “Standard Test Method for Individual Piles Under Static Axial Tensile Load”[3]. The apparatus used in the load test program comprised of the reaction force, loading system and measurement device. For reaction force, an excavator or piling machine on site is used to be a reaction force during test.

![Figure 3 ground screw pile installation by piling machine](image)
It mounted on top of the test pile for compression test program. For tension test program, two bearing plates on both sides of test pile are used to be a reaction force during test. Tension load was transferred from hydraulic jack pass a strong main beam to two plates. Loading system is applied by hydraulic jack that has capacity more than tested load will be used to apply the test load. The calibration for the hydraulic jack should be performed before each testing program. Two dial gauges were mounted with magnetic stands on reference beam to measure the test pile vertical displacement. The gauges have a travel length of 50 mm with an accuracy of 0.01 mm. A small steel beam was cross-connected and laid on the support firmly embedded in the ground acted as reference beam. The details for compression load testing program and tension load testing program are described as followed.

3.1 Ground screw pile compression testing
This testing proved the pile compression load capacity of ground screw steel pile PV panel mounting structure. The tested compression load was applied by a system of hydraulic jacks acting against an excavator. Two dial gauges were mounted on independently support to measure the settlement of pile head. The devices installation diagram and in-situ devices set up picture were shown in Figure 4 and 5 respectively.
Unless failure occurred, the pile will be loaded to 200% of maximum calculation load, applying the load in increments of 25% of calculation load and maintain each load increment until the rate of settlement is not greater than 0.25mm/h. Each test load increment will be maintained until the rate of settlement or upward movement in less than 0.25 mm/hr. or 2 hour has elapsed whichever occurs first. Then increase to the next load increment. Settlement reading will be recorded after the application of each test load increment at 0, 1, 5 and 10 minutes elapsed time for the corresponding test load. After the required load, holding the maximum load at least 1 hr. and remove the test load in decrements 25% of the total test load with 1 hr. between decrements. For the result of testing, the relation of test load and pile settlement was plotted as shown in Figure 6.
3.2 Ground screw pile tension testing

This testing proved the pile tension load or pull-out capacity of ground screw steel pile PV panel mounting structure. The tension load or pull-out forces occur from wind beneath the PV panel. The tested tension load was developed from hydraulic jack and transferred pass a strong beam to two bearing plates which installed on both sides of test pile will be used to be a reaction force during test. Two dial gauges were also mounted on independently support to measure the displacement of pile head. The devices installation diagram and in-situ devices set up picture were shown in Figure 7 and 8 respectively.
The loading condition and upward movement monitoring will be same procedure as the compression test. For the result of testing, the relation of test load and pile movement was plotted as shown in Figure 9.

The test pile will be loaded to 200% of both design loads if pile failures do not occur. The term “failure” as used in ASTM test method indicates a rapid progressive settlement for compression test or upward movement for tension test of the test pile under a constant or decreasing load. If pile failure occurs continue jacking the pile until the movement equals 15 % of the pile diameter tested. The pile capacity will be determined at the load before failure was detected.

4. Conclusions
The capacity of steel ground screw pile using for foundation of PV panel mounting structure can be proved by in-situ load test both of compression and tension (pull-out). From design
report of solar farm in Thailand [4], the pile compressive reaction load is between $400 - 600 \text{ kg}$ while pull-out reaction load is between $600 - 900 \text{ kg}$ depended on project location and terrain. The pile capacity load tests were performed in 12 solar farm projects around of Thailand. The pile length in each project was varied between $1.00 - 1.60 \text{ m}$ upon the characteristic of sub soil properties. For compression load test, ground screw pile can supported test load $800 - 1,200 \text{ kg}$ with pile settlement not greater than $15\%$ of pile diameter. For tension load test, ground screw pile can restrained pull-out test load $1,200 - 1,800 \text{ kg}$ with pile upward not greater than $15\%$ of pile diameter.

References
Wastewater Containing Chromium (Cr) Management Using Water Cabbage (Pistia Stratiotes) as Bioremediator in Different Size and Exposure Time

Zakiyah, U*, and I.W. Rahmawati
Brawijaya University
*umi.zakiyah@gmail.com

Abstract

Many industrial industry produce wastewater that containing heavy metal chromium (Cr) which significantly harmful to biota in aquatic environment. Water Cabbage (pistia stratiotes) is water plants species that has adsorption capacity can be used as a bioremediator agent in heavy metal pollution. This research was aimed to observe the influence of different plant size (small, medium and larges) and exposure time and the interactions of between those two parameters of Pistia stratiotes in Cr absorption by determining the Cr concentration in the medium, leaf and root of the plant. The experiment used Completely Factorial Randomized Design with two factors: the size and exposure time with three replicates and was conducted in the laboratory of Fish Reproduction, Faculty of Fisheries and Marine Science, and Chemical Laboratory of Basic Science Faculty Brawijaya University Malang in February 2015. The results showed that within 8 days, the concentrations of Cr in the media with largest size of the water cabbages which previously was 20 ppm has decreased up to 9.28 ppm or reduced by 53.6 %, while with the smallest size of the water cabbage Cr concentration can decreased from initially 18,05 ppm becomes 11,73 ppm, or 46.33% and in the media with medium-size of the water cabbage the Cr concentration decreased from previously 17,43 ppm becomes 10,73 ppm or reduced by 42.33 %. The average concentration of Cr accumulated in the smallest, medium and largest water cabbage root start were obsered starting from day 2 till day 8 showed range between 1.03-3.45 ppm, 1.28-4.39 ppm, and 1.78-5.68 ppm. The average concentration of Cr that accumulates on the small size leaf, medium and large start 2 still 8 days on average range between 0,13-0,73 ppm, 0,21-0,24 ppm, and 1,06-1,38 ppm. The ANOVA analysis showed that there were significant differences between sizes and exposure times as well as their interaction of these two parameters in the Cr absorptions. The highest absorptions of the Cr accumulation was found in the interactions between large plant root and 8 days exposure times. This result showed that Cr concentration in root and leaf will keep on increasing with the increase of planting times and sizes.

Keywords: Wastewater management, water cabbage, heavy metal Cr.
ICEAI-1217
High-Temperature Corrosion of T22 Steel in N2/H2S-Mixed Gas

Min Jung Kim, Dong Bok Lee*
School of Advanced Materials Science and Engineering, Sungkyunkwan University, Suwon
16419, South Korea
*dlee@skku.ac.kr

Abstract
T22 steel (Fe-2.25Cr-1Mo in wt.%) was corroded at 600 and 700 °C for 5-70 h under an atmospheric pressure that consisted of N2-(0.5, 2.5)%H2S-mixed gas. T22 steel corroded rapidly, forming outer FeS scales and inner (FeS, FeCr2O4)-mixed scale. The formation of the outer FeS scale facilitated the oxidation of Cr to FeCr2O4 in the inner scales. Since the nonprotective FeS scale was present over the whole scale, T22 steel displayed poor corrosion resistance.

Keywords: Fe-Cr-Mo alloy, T22 steel, corrosion, sulfidation, H2S gas

1. Introduction
The integrated gasification combined cycle (IGCC) power plants are operating in U.S., Japan, Germany, and Netherlands. It is a new technology that turns coal into synthesis gas (syngas) and produces the electricity. It promises low emissions and improved efficiency compared to conventional coal-fired power plants that produce the electricity directly by burning coals. However, one of the main problems in IGCC is the corrosion occurring by the syngas in a gasification unit, because the syngas consisted primarily of the extremely corrosive H2S gas. This limits the operating temperature and the process efficiency of the IGCC power plants. It is noted that the H2S gas has been a major concern in oil refinery plants, high-temperature gas turbines, and petrochemical units. H2S gas dissociates into sulfur and hydrogen ions, and reacts with the steel according to the reaction; H2S+Fe → FeS+H2 [1,2]. Generally, most sulphides are highly nonstoichiometric, and ionic diffusion in the scales is hence quite fast [3,4]. Sulfidation is therefore a quite serious problem. Hydrogen also significantly decreases the corrosion resistance and mechanical properties of the steel [5,6].

In this study, T22 steel (Fe-2.25Cr-1Mo in wt.%) was corroded at 600 and 700 °C for up to 70 h in N2-(0.5, 2.5)%H2S-mixed gas in order to understand its corrosion behavior in the H2S-mixed gas. This is important in IGCC power plants, oil refinery plants, high-temperature gas turbines, and petrochemical units. Although the oxidation behavior of T22 steel was extensively studied [7,8], little is reported about the high-temperature corrosion behavior of
T22 steel in H₂S-mixed gas. The purpose of this study is to investigate the corrosion behavior of T22 steel in N₂/H₂S-mixed gas.

2. Experimental Details

T22 steel plate with a nominal composition of Fe-2.25Cr-1.0Mo-0.45Mn-0.3Si-0.12C in wt% were cut into a size of 2x10x15 mm³, ground up to a 1000-grit finish with SiC paper, ultrasonically cleaned in acetone, corroded, and inspected to examine its corrosion behavior. Each sample was suspended by a Pt wire in a quartz reaction tube positioned vertically inside the hot zone of the vertical electrical furnace, and corroded at 600 and 700 °C for up to 70 h in N₂-(0.5, 2.5)%H₂S-mixed gas maintained at 1 atm. The employed N₂ gas was 99.999% pure, and H₂S gas was 99.5% pure. The corroded samples were characterized by a scanning electron microscope (SEM), an X-ray diffractometer (XRD) with Cu-Kα radiation, and an electron probe microanalyzer (EPMA).

3. Results and Discussion

The corrosion kinetics of T22 steel in N₂-(0.5, 2.5)%H₂S gas are depicted in Fig. 1. Weight gains were the sum of weight gain due to scaling and weight loss due to scale spallation. They increased with an increase in the temperature and the H₂S concentration. The fastest corrosion rate was observed in the sample corroded at 700 °C in N₂-2.5%H₂S-mixed gas. The almost linear, large weight gains depicted in Fig. 1 indicate vastly fast corrosion kinetics for all the samples. It is noted that local cracking, partial spallation and void formation in the formed scales were unavoidable for all the samples. Such scale failure became more serious as corrosion progressed. Although T22 steel displayed reasonable oxidation resistance in the oxidizing atmospheres, it was nonprotective in the harsh H₂S-mixed corrosion environment.
Fig. 2 indicates that T22 steel consisted of α-Fe. In this study, the corrosion at 600 and 700 °C for 5-70 h in N₂-(0.5, 2.5)%H₂S-mixed gas inevitably led to the formation of the outer FeS scale and the inner (FeS, FeCr₂O₄)-mixed scale. Fig. 2b indicates the outer FeS scale that formed after corrosion at 700 °C for 20 h in N₂-2.5%H₂S gas. The outer, nonadherent FeS scale was detached off by slightly hitting the sample, and the inner scale was X-rayed as shown in Fig. 2c. This revealed the inner (FeS, FeCr₂O₄)-mixed scale, along with the α-Fe matrix phase. The amount of Cr in T22 steel was not large enough to completely cover the matrix surface with the protective Cr₂O₃ scale. T22 steel reacted with the H₂S gas to form FeS, releasing hydrogen according to the equation; Fe(s)+H₂S(g) → FeS(s)+H₂(g). Since FeS has a very high concentration of cation vacancies, it grew fast to form the outer scale through the outward diffusion of Fe²⁺ ions [6]. The formation of FeS decreased the sulfur potential, and thereby the oxygen potential underneath, facilitating the formation of the oxides in the inner scale, as shown in Fig. 2c. The impurity oxygen in N₂-(0.5, 2.5)%H₂S-mixed gas reacted with T22 steel according to the equations; Fe(s)+1/2 O₂(g) → FeO(s), and 2Cr(s)+3/2 O₂(g) → Cr₂O₃(s). Thermodynamically, the oxides are generally more stable than the corresponding sulfides. The formed FeO and Cr₂O₃ oxides further reacted to form the more stable FeCr₂O₄ spinel according to the equation; FeO(s)+Cr₂O₃(s) → FeCr₂O₄(s).
The morphology of surface scales that formed on T22 steel after corrosion in \( \text{N}_2-0.5\%\text{H}_2\text{S} \) gas is shown in Fig. 3. From the early corrosion stage at 600 °C, FeS platelets progressively protruded through the ensuing outward diffusion of \( \text{Fe}^{2+} \) ions over the smooth underlying scale (Figs. 3a and b). They spalled off easily due to their fast growth rate and incorporation of hydrogen released from the \( \text{H}_2\text{S} \) gas. The formed scales were quite fragile so that cracks were seen in Fig. 3a. At 700 °C, the FeS platelets grew to coarse, protruded FeS grains, as shown in Fig. 3c. As corrosion progressed, FeS grains grew bigger, leading to the generation of cracks in the surface FeS scale (Fig. 3d).

The morphology of surface scales that formed on T22 steel after corrosion in \( \text{N}_2-2.5\%\text{H}_2\text{S} \) gas is shown in Fig. 4. From the early corrosion stage at 600 °C, coarse, facetted FeS grains covered the whole surface (Fig. 4a). They continuously grew bigger as the corrosion progressed (Figs. 4b-d). In Fig. 4d, cracks propagated inter- and trans-granularly. Figs. 3 and 4 clearly indicate that the \( \text{H}_2\text{S} \) gas accelerated corrosion.
Fig. 5 shows SEM/EDS analytical results of T22 steel after corrosion in N\(_2\)-0.5%H\(_2\)S gas at 600 °C for 70 h. The scale consisted of about 120 μm-thick outer scale, and about 70 μm-thick inner scale. The outer scale was detached from the inner scale, and vertical cracks were seen in the inner scale, owing to the large stress arisen by (1) the mismatch in the thermal expansion coefficients among the outer scale, inner scale, and the matrix, (2) the difference in the growth rates of various oxides and sulfides, and (3) the hydrogen dissolution in the scale. The EDS analysis indicated that the outer scale and the inner scale consisted primarily of Fe\(_2\)S (Fig. 5b), and (FeS, FeCr\(_2\)O\(_4\)) (Fig. 5c), respectively. This was consistent of the XRD results depicted in Fig. 2. FeS platelets protruded over the outer FeS scale (Fig. 5a).

4. Conclusions

T22 steel was corroded at 600 and 700 °C for up to 70 h in N\(_2\)/H\(_2\)S-mixed gas under total pressure of 1 atm. The corrosion occurred almost linearly through the sulfidation, together with oxidation to a less extent. The outer scale consisted primarily of Fe\(_2\)S that formed by the outward diffusion of Fe\(^{2+}\) ions. The inner (FeS, FeCr\(_2\)O\(_4\))-mixed scale formed by the inward diffusion of predominantly sulfur and a small amount of oxygen. The outer scale kept growing outwards during corrosion. The formed scales were nonadherent, and susceptible to cracking.

Acknowledgments

This work was supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant (No. 20143030050070) funded by the Korea government Ministry of
Trade, Industry and Energy.

5. References
ICEAI-1172
Engineering Education for Sustainable Development: An Innovative Approach
Eric Tsun-Tat Wong | The Hong Kong Polytechnic University

ICEAI-1111
An iOS Application development for Location Recommendation of Rajamangala University of Technology Isan
Inchaya Charoensukbenja | Rajamangala University of Technology Isan
Jiraporn Bunjong | Rajamangala University of Technology Isan
Nuntanakorn Chumpon | Rajamangala University of Technology Isan
Apichit Kampala | Rajamangala University of Technology Isan

ICEAI-1089
Study on the Relationship between Class Evaluation and Consistency in Remarks, based on the Similarity of University Teacher’s Remarks with Term Definition
Shuya Nakamura | Tokyo University of Science
Susumu Fujimori | Tokyo University of Science
Takako Akakura | Tokyo University of Science

ICEAI-1008
Minimum-Energy Trajectory Planning Based on Hamiltonian Function for a Mechatronic Motor-Table System
Kun-Yung Chen | Air Force Institute of Technology

ICEAI-1053
Probe Typed Microcavity Fiber Fabry-Pérot interferometer for Simultaneously Sensing Refractive Index and Temperature
Wei-Kang Chang | National United University
Meng-Shan Wu | National United University
Chung-Hao Tseng | National United University
Cheng-Ling Lee | National United University
ICEAI-1172
Engineering Education for Sustainable Development: An Innovative Approach

Eric T.T. Wong
Department of Mechanical Engineering, The Hong Kong Polytechnic University, Hong Kong
mmttwong@polyu.edu.hk

Abstract
Subsequent to the United Nations Educational, Scientific and Cultural Organization (UNESCO) call for Global Action on Education for Sustainable Development (ESD), universities throughout the world are placing importance on ESD (UNESCO, 2005; UNESCO, 2011) and have tried various means to facilitate their students in the acquisition of the knowledge, skills, attitudes and values necessary to shape a sustainable future. ESD is about lifelong learning, and is an integral part of quality education. ESD is holistic and transformational education which addresses learning content and outcomes, pedagogy and the learning environment (Lotz-Sisitka, 2014). It covers four main areas: social and economic justice, cultural diversity, human rights of future generations and the protection and restoration of the Earth’s ecosystems. It also stresses the importance of critical thinking, inter-disciplinary, multi-method approaches to assessment and challenging approaches to, and ideas about, teaching and learning. The engineering faculty of The Hong Kong Polytechnic University has implemented an approach which, besides meeting the UNESCO call for ESD, also complies with the undergraduate program accreditation requirements of the Hong Kong Institution of Engineers – A signatory of the Washington Accord. The Washington Accord, signed in 1989, is an international agreement among bodies responsible for accrediting engineering degree programs. It recognizes the substantial equivalency of programs accredited by those bodies and recommends that graduates of programs accredited by any of the signatory bodies be recognized by the other bodies as having met the academic requirements for entry to the practice of engineering (International Engineering Alliance, 2016). Through a Lecture-cum-Presentation (LCP) teaching approach, ESD was incorporated into the undergraduate curriculum and students demonstrated a better chance of developing the necessary professional outlook and workplace skills as advocated by UNESCO. This paper detailed the LCP approach, which essentially shows how a SD subject can be modified with minimal teaching effort to achieve some important UNESCO goals. Supporting evidence was obtained through self-reflection statements obtained from students.

Keywords: Sustainable Development Education, Lecture-cum-Presentation.

1. Background
According to UNESCO, Education for Sustainable Development (ESD) allows every human being to acquire the knowledge, skills, attitudes and values necessary to shape a sustainable future. ESD is defined in a broad manner covering four main areas: social and economic justice, cultural diversity, human rights of future generations and the protection and restoration of the Earth’s ecosystems. It stresses the importance of critical thinking, inter-disciplinary, multi-method approaches to assessment and challenging approaches to, and ideas about, teaching and learning.

Hence it is a high priority for the global higher education sector to reorient educational systems and curricula towards these needs. Incorporating ESD into the undergraduate curriculum is not about changing what we do, it is about doing what we do, differently. It does not require every module to include lectures on sustainability. It is highly likely that there are already aspects of sustainability taught but not explicitly referenced. It is up to each academic staff to interpret ESD as applicable to their own discipline.

The aim of this paper is to illustrate a teaching approach adopted within the Engineering Faculty of the Hong Kong Polytechnic University (PolyU). The Lecture-cum-Presentation approach has been favorably received by students of over 10 undergraduate engineering degree programs.

In the following sections, significance of the SD subject bearing the title “Society and the Engineer” towards professional engineering qualifications is first given. Characteristics of the proposed teaching method are then detailed. Finally the responses of students participating in the Lecture-cum-Presentation teaching is evaluated through their self-reflection statements.

2. Significance of the SD subject: Society and the Engineer
As one of the signatories of the Washington Accord, the Hong Kong Institution of Engineers (HKIE) expects that all engineering degree programs requiring accreditation should demonstrate that their graduates have certain attributes and these are listed in Table 1.
To comply with the HKIE accreditation requirements, the PolyU Engineering Faculty has designated the subject “Society and The Engineer” as a compulsory subject for all the engineering programs - computing, electrical engineering, electronic and information engineering, industrial and systems engineering, mechanical engineering and biomedical engineering. The subject syllabus covers eight dimensions, viz. historical, professional, economic, social and cultural, legal, healthy and safety, and environmental. The intended learning outcomes have been specified as the ability to:

- Understand professional and ethical responsibility,
- Communicate effectively,
- To stay abreast of contemporary issues,
- To recognize the need for and to engage in life-long learning, and
- Understand the impact of engineering solutions in a global and societal context, especially the importance of health, safety and environmental considerations to both workers and the general public,

The following sessions illustrates how these professional outlook and workplace skills can be developed through the Lecture-cum-Presentation (LCP) approach.

### 3. Proposed Method – LCP approach

Traditionally the subject “Society and the Engineer” was mainly taught in a lecture and tutorial style. The major disadvantages of this approach include little chance of clarification of difficult concepts in mass lectures, little improvement in written and oral communication skills, no
teamwork training, no peer review and little chance of learning from peers. To overcome these shortcomings, LCP approach was developed. Students are formed into groups and they can propose any engineering project as their presentation theme. Nature of this project can be regional or international. A short lecture on each dimension is given at least one week before the presentation. At the beginning, students were told that the subject aims to develop their awareness and critical thinking about the relationship between engineering and the society. Therefore the development of critical thinking skills is very important. Basically what they need to do there is: “Speak out, voice your opinion, and construct your arguments”.

Then student were told about learning activities to be expected:

(1) Case Analysis
After each class, students are asked to discuss in their group to analyze the project with reference to the societal dimension discussed in that week and summarize the conclusion of the group analysis in bullet points in ONE page. For instance, Professional dimension was taught in Week 3 (Table 2) and every group would give their presentation in Week 4. Students were given essential materials briefly in the lecture including reasons for the formation of professional bodies, the Washington Accord, the routes to become registered professional engineers, the code of ethics, etc.
(2) Weekly Presentation
Each group has to present one dimension based on the analysis of the case. The audience groups would provide critical comments and feedbacks and fill out Feedback Forms to the presenter group for their reflection. The feedback forms were submitted at the end of class. Contents of the Feedback Form are:

- **Points that the group agreed** (Evidence/experience that supplement or backup the points mentioned to be given)
- **Points that the group disagreed** (Reasons to be given)
- **General comments**
- **Reflections**

(3) Guest Seminars
There were two seminars. The first one was given by a speaker from the Independent Commission Against Corruption and the second one by a representative from the HKIE. Both speakers stressed the importance of professional ethics.

(4) Final Presentation
Based on group analysis, feedback on dimensional presentation and other materials in each project, each group had to prepare an overall presentation to demonstrate the relationship of the engineering project with the society.

(5) Self-Reflection Statement
Each group had to submit a Self-Reflection Statement based on their learning experience (2 pages, font 12 in MS WORD format, Hard copy).

(6) Sustainable Development (SD) Competition
All groups’ projects had to enter the Sustainable Development (SD) Competition. For preparation of the Competition, students were given a list of references and asked to refer to the Guiding Principles of Sustainable Development (Royal Academy of Engineering, 2005). In particular, students were asked to consider the following list of questions during their preparation:

- What are the main historical and current causes (i.e. physical, social, cultural, or economic) of the issue?
• What are the geographic scale, the spatial distribution, and the longevity of the issue?
• What are the major risks and consequences to the natural environment?
• What are the major risks and the consequences to human systems?
• What are the economic implications?
• What are the major solutions that are currently implemented or proposed?
• What are the obstacles to these solutions?
• What major social values (e.g. economic, ecological, political, aesthetic) are involved in or infringed on by these solutions?
• What group(s) of people would be adversely impacted by or bear the cost of these solutions?
• What is the political status of the problem and solutions?
• How is this issue connected to other issues?
• What change can you make or have made in your daily life to lessen the issue?
• Beyond changes in your daily life, what is the next step you could take to address the issue?

In respect of their SD Competition submission, each group had to submit the following:
• A 2-page executive summary (Times New Roman, 12pt, single space, 700 ~ 800 words)
• A powerpoint presentation which visually explains the SD concept integrated into dimensions: social, culture, economic, legal, health and safety, environment and welfare of the society

Best 5~7 groups were selected and recommended to present their cases in the seminar Session. Each group’s presentation would last 10 minutes with 5 minutes Q&A.

4. Results
Responses of students towards this approach were evaluated through group self-reflection statements collected and they were categorized below:

4.1 Acquisition of SD Knowledge
“The course introduced the eight dimensions of engineering and we gained valuable knowledge from them. From the Historical Dimension, we understood the importance of reviewing past experience and applying those into current situations. For the Professional Dimension, through the lecture and the seminar gave by the representative of the Independent Commission Against Corruption, we understood the role and ethical responsibilities needed as an engineer. As mentioned in the Legal Dimension lecture, it is always important for us to identify the responsibilities and liabilities of various stakeholders. For the Economical Dimension, we learnt some basic concepts like demand and supply and some current issues like the
opportunities brought along with The Mainland and Hong Kong Closer Economic Partnership Arrangement. In the Social and Cultural Dimensions, the linkage between the engineering field and the development of our society is emphasized. For the Environmental Dimension, we understood the role of an engineer to protect the natural environment. For the Health & Safety Dimension, we understood the importance of risk assessment and risk management.

The most important thing that we have learnt is to strike a balance between different dimensions in accordance to various stakeholders so as to achieve local sustainable development.

The SD Case Competition made us realize that sustainability is a paradigm for thinking about a future in which environmental, social and economic considerations are balanced in the pursuit of development and an improved quality of life. The three spheres – society, environment and economy – are intertwined. In particular, a prosperous society relies on a healthy environment to provide food and resources, safe drinking water, and clean air for its citizens.”

4.2 Communication Skills

“In addition to weekly lectures, the course incorporated activities like group presentations and quiz competitions, which have equipped us with diverse abilities. After deciding the presentation topic, we need to search information related to our topic and this enhanced our data collection skills. The collected information includes government documents, newspaper clips, academic journals and reference books. The bulk information collected must first be evaluated and analyzed before completing the literature review and the preparation work of PowerPoint slides. After data collection, group members are expected to share their information among the group and cooperate with other group members to arrange information systematically. This improved our communication skills through team cooperation.

In this course, we had two chances to have a presentation. In the first lecture, our lecturer showed us previous students' presentation PowerPoints and taught us how to make the presentation professional and comprehensive, such as the inclusion of engineering computations and international comparison. We all had a presentation on each of the eight dimensions first. After each presentation, our classmates and the lecturer gave us feedback information for improvement in the second presentation. In our case, we should discuss the problem from the viewpoints of various stakeholders. We also learn some soft skills of presentation such as adding page number and be lively during the presentation. These are important skills for us in the future.
In summary, the presentation sessions trained our written and verbal communication skills, including the techniques of content selection and delivering information effectively through both PowerPoint slides and verbal presentation. During Q&A sessions, we also learned how to deal with challenging questions collectively.”

4.3 Awareness of global issues
“During lessons, students have chances to discuss about world issues related to different dimensions of engineering. Classmates and the lecturer shared world news which inspired us of awareness in paying attention to global issues such as the impact of climate change, as well as learning by self-initiation, like reading news every day. We have also discussed future career development as an engineer. It has reminded us the importance of ethical issues related to our profession. Hence we knew what we should do or should not do as an engineer.”

4.4 Critical thinking
“As we were asked to form groups we realized that individual group member would be responsible for one another's learning, otherwise we could not achieve high marks in group activities. Hence during the preparation of presentations, class quizzes and SD case competitions, and completion of feedback forms, there were active discussions and exchange of ideas within our group. Consequently I learnt that for an engineering problem, besides critically analyzing it from the technical perspective, I need to evaluate the impact of sustainable development issues such as ethical, environmental, health and safety, social and cultural, as well as the economic sustainability of the proposed solutions”.

4.5 Life-long learning
“No one can be perfect even he knew a lot of things as there is always room for improvement. The course “Society and Engineer” has taught us the importance of life-long learning for engineer. Lifelong learning is the continuous building of skills and knowledge throughout the life of an individual. There is an increasing need for us to continually update knowledge and skills to match technological developments due to the rapid advancement of technology. For example, in order to become a HKIE member, Continuing Professional Development is a mandatory requirement.”

4.6 Time Management
“Through the lecture plan given to us, we knew the importance of planning and management in a group project. For example, in weeks 2 and 3 we had to make sure what was needed to be done before or during the project presentation. If we did not have a good plan, we cannot achieve our goals. We learnt that in real life situations, time is always limited. For an engineer, we need to finish everything in a limited period. A good example for time management is our presentation, we need to plan ahead the responsibility of each classmate, set a deadline for each
one and set a deadline for every task. The group leader needs to come up with a plan agreed by all group-mates, otherwise the whole process would be delayed. Just like the Industrial Centre training, time management is important for the success of a project.”

4.7 Teamwork
“Forming a group with unfamiliar classmates is itself a challenge for us. However, the lecturer told us that this is similar to our future workplace situation and we bought his view. Since the assessment of this subject includes teamwork, such as group presentations, presentation summary, group feedbacks and SD competition, we had to face several challenges. The first challenge of our team was choosing the topic of presentation. At first, we had different opinions on choosing the topic and we argued a lot and could not make the decision. Finally, through the leader’s persuasion some teammates no longer stood firm on their views. From this experience, we learnt the importance of compromise. Compromise does not represent weakness, but maturity.

The second challenge is the arrangement of the final presentation, since the linking of each dimension in a project is crucial. This subject offered us a chance to learn to plan the presentation strategically, as some dimensions could be presented by more than one member, e.g. the environmental dimension, and some dimensions can be combined to be presented by one member, e.g. health and safety dimension. It is because in the final presentation, every member was required to have a presentation of not more than 8 minutes. Therefore, for a cohesive and coherent presentation it is important to make sure every member has sufficient and appropriate content for their part of the presentation.

The third one is team spirit. This subject gave us a golden chance to feel and learn to develop team spirit. Due to the different choice of elective subjects, setting a meeting date and time suitable for all groupmates was not an easy task, and this taught us to respect each other. After that, we know how important the team spirit is and how a team should run. This helps and equips us the ability to cooperate with different people during a given task. We also realized that due to good team spirit the efficiency of a team is much better than that of the individual member.”

4.8 Learning from peers
“From the feedback forms, the comments from the other groups showed that more objective evidences should be included to support the information we mentioned in the presentation such as published statistics and research literature. In addition, sustainable development should also be focused on dimensions other than technology. With these comments, we improved our final presentation. For instance, sustainable development and relationship between society and engineering were considered.”
In conclusion, it can be seen that through the Lecture-cum-Presentation teaching approach most students would have a better understanding of professional and ethical responsibility, learn how to evaluate the impact of engineering solutions in a societal context and have improved their communication skills moderately. They recognized the importance of peer learning, critical thinking, teamwork and time management. They were also aware of the need for keeping abreast of contemporary issues and to engage in life-long learning.

5. References


ICEAI-1111
An iOS Application development for Location Recommendation of Rajamangala University of Technology Isan

Inchaya Charoensukbenja\textsuperscript{a,b,*}, Jiraporn Bunjong\textsuperscript{b} Nuntanakorn Chumpon\textsuperscript{b} and Apichit Kampala\textsuperscript{c}

\textsuperscript{a,b} Department of Multimedia Technology, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan, Nakhonratchasima, Thailand
\textsuperscript{c} Department of Civil Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, KhonKaen Campus, Khon Kaen, THAILAND

meenwana.ch@gmail.com

Abstract
The three main objectives of this research are 1) to develop an iOS application for location recommendation within Rajamangala University of Technology Isan area 2) to study the location recognition responses from the sample target group from the use of location recommendation application of Rajamangala University of Technology Isan and 3) to study the results of satisfaction levels from the sample target group from the use of location recommendation application of Rajamangala University of Technology Isan. The sample target group consists of 99 first-year students of Rajamangala University of technology Isan which were sampled based on ‘accidental sampling’ method. The results showed the average score of 4.62 (within the highest level range) on application quality given by the experts, the recognition results of 89.60 percent (within the highest level range) by the sample group and the satisfaction level average score of 4.64 (within the highest level range) by the sample group.

Keywords: Application, iOS, Rajamangala University of Technology Isan, Map 2D

1. Background/ Objectives and Goals

a. Introduction
Due to the rapid growth in technology advancement nowadays, mobile applications have become important tools for accessing to individual, organizational or educational information. For example, to access public information, to search locations or routes, etc. Nevertheless, there are still limited number of in-country applications such as applications to recommend universities in the provincial areas. Given an example, Rajamangala University of Technology Isan, Nakhonratchasima Province, still has the simple one dimensional map and only with the building names on the map without any further information available such as main characteristics of the location, important information related to the buildings, or navigating system. Therefore, the current system has not yet met the key objectives of the application
where it is still too difficult to access the required information and not yet systematic for the new users such as new students or external people.

As a consequence, this research has been proposed to develop a mobile application called RMUTIMap on iOS operation system. This application is now available under Navigation application group in App Store. This application is an alternative and convenient tool to search information related to public communications, buildings or locations within Rajamangala University of Technology Isan.

This application presents maps in isometric projection view. The isometric projection is one of the two dimensional illustrations where the three dimensional image is visualized from the angle of the defined starting point. To build an isometric projection image, the length of each side of the object is the size as depicted in the isometric projection image. The two sides of the image are always drawn at 30 degrees from the horizontal axis.

When a user requests to access any of the information within any section of Rajamangala University of Technology Isan, the request is responded immediately with navigation through web sites of each faculty and major field of Rajamangala University of Technology Isan.

The developed application can be applied for the real use in Rajamangala University of Technology Isan and has been proved to efficiently provide route information and other information from each faculty and major field of Rajamangala University of Technology Isan (Serdar, 2011).

1.2 Research Objectives
1. To develop an iOS application for location recommendation of Rajamangala University of Technology Isan.

2. To study the location recognition responses from the sample target group from the use of location recommendation application of Rajamangala University of Technology Isan.

3. To study the results of satisfaction levels from the sample target group from the use of location recommendation application of Rajamangala University of Technology Isan.

2. Methods
The iOS application development for location recommendation of Rajamangala University of Technology Isan is based on design framework of ADDIE Model (Chatpong, 2011) which are divided into 5 main phases as Phase 1 – Analysis, Phase 2 – Design, Phase 3 – Develop, Phase 4- Implementation, and Phase 5 – Evaluation.
2.1 Development of iOS application for location recommendation of Rajamangala University of Technology Isan

The iOS application development for location recommendation of Rajamangala University of
Technology Isan based on ADDIE model was divided into 5 main phases as following:

**Phase I Analysis:**
Collect and analyze information required to develop application and define target group.
Study and analyze research related information and documentation.
Gather the information and plot in BrainStorm Chart, Concept Chart and Content Network.

**Phase II Design:**
Design the navigation system, presentation format, content structure and path, and evaluation methods.
Draw system flowchart showing sequences and module relationships.
Design interface layout, user interface and layout of the location map in the university in the form of isometric projection.

**Phase III Development:**
Based on the information from the earlier phases, the iOS application for location recommendation of Rajamangala University of Technology Isan was developed according to the system flowchart which determined relationships of each application module. On the location map, the specific content topic can be selected via content menu which is linked to the corresponding content or the next level menu.

The application artwork for application development based on the designed interface layout, user interface and the isometric projection map layout was built.

Content list system is designed in the form of infographic menu with the sequential list of all faculties and locations in the university so that complete information is available for user access. All contents of route navigation and faculty information are shown under the same standard frame and form including menu, colors, fonts and content structure. The application has been designed to be user interactive based on content navigation which links to the corresponding target. The application provides fast response in all pages of application in displaying results or returning back to the previous position. The content has been designed to be presented by animated characters mimicking students from the four faculties of Rajamangala University of Technology Isan. The characters present and recommend each location on the isometric projection angle with the whole picture of the university in the two dimensional illustration visualized from the elevated angle of 30 degrees on both sides (Apple Inc., 2013a; 2013b). The application layout icon is square shape. The map pin icon has been used. The web site address information of each faculty and major field is tagged with the icon to link to the selected faculty and major field related information.
**Phase IV Implementation:**
The application was tested by content and media experts for the accuracy and suitability of the content. The navigation system has been adjusted to be under the same standard for all pages. The developed application was tested by the sample target group (Rachelle, 2012).

**Phase 5 Evaluation:**
The performance and efficiency of this media were measured by recognition results and user satisfaction levels. The results were statistically processed and analyzed, discussed and concluded.

---

![Diagram 1](image1.png)

**Figure 2: Component and interface layout**

![Diagram 2](image2.png)

**Figure 3: Layout of isometric projection map page**
Figure 4: First page (application introduction)
2.2 Performance measurement for the develop iOS application
The performance measurement was done by evaluating the location recognition of the sample group and satisfaction level on the use of application from the sample group.

2.3 Analysis and Evaluation
The application was tested by the sample group from the first year students of Rajamangala
University of Technology Isan.

2.4 Research Tools
1. The iOS application for location recommendation of Rajamangala University of Technology Isan;
2. Evaluation form for experts to fill in to evaluate performance of location recommendation application of Rajamangala University of Technology Isan;
3. Evaluation form for sample groups to fill in to evaluate their location recognition from the use of location recommendation application of Rajamangala University of Technology Isan;
4. Satisfaction survey form for sample groups to fill in after the use of location recommendation application of Rajamangala University of Technology Isan.

3. Results and Discussions
3.1 Presentation of the developed iOS application
There are 3 groups presented in the application – 1) locations of each faculty 2) buildings 3) web site location of each faculty and major field. Users interact with the application via multi-touch screen, the key iOS device feature, and could manage the screen object on the square icon. The map pin icons and standard symbols help users conveniently use the application. Experienced users will be easily familiar with application usage and locations.

3.2 Performance of the developed iOS application
From the result analysis, the performance evaluation from the experts on the three quality aspects had an average score of 4.62, which is in the highest level range. By considering each quality aspect, it was found that the content quality received the highest average score of 4.80 which is the in highest level range. The next highest average score was on technical aspect which received an average score of 4.72 which is also in the highest level range. The lowest average score was on design aspect which had an average score of 4.33 which is in the high level range. The results were summarized in Table 1. The location recommendation application of Rajamangala University of Technology has been designed and developed based on ADDIE Model with the appropriate content arrangement.
3.3 Location recognition results from the sample group
The location recognition results of 89.60%, with the highest level range, from the sample group from the use of the location recommendation application for Rajamangala University of Technology Isan showed an efficient result of the application usage. With a good design for mobile device application and the use of isometric projection, the sample group can remember the main characteristics of the buildings. Furthermore, the map has been designed to make an attractive illustration. The options for pop-up or list result are also available.

3.4 Satisfaction results from the sample group
From the satisfaction survey of the sample group after the use of location recommendation application for Rajamangala University of Technology Isan, the satisfaction result was an average of 4.64, which is in the highest level range. The high level of satisfaction was mainly due to the user-oriented design of the application which makes the application easy to use with attractive graphics and motion pictures.

4. Research Conclusions
The application development results of the location recommendation application of Rajamangala University of Technology Isan can be concluded as following:
1) Application performance evaluated by the experts had an average score of 4.61 which is in the highest level range.
2) The location recognition results from the sample group after the use of application was 89.60% which is in the highest level range.
3) The satisfaction results of the sample group had an average score of 4.64 which is in the highest level rage.
5. Acknowledgments

Acknowledgements: This work was supported by Rajamangala University of Technology Isan.

6. References


ICEAI-1089
Study on the Relationship between Class Evaluation and Consistency in Remarks, based on the Similarity of University Teacher’s Remarks with Term Definition

Shuya Nakamura⁎, Susumu Fujimorib, Takako Akakurab

a Graduate of Engineering, Tokyo University of Science, Japan
b Faculty of Engineering, Tokyo University of Science, Japan

⁎nakamura@ms.kagu.tus.ac.jp

Abstract
Teachers are expected to provide correct and orderly explanations, particularly in university lectures demanding a high level of expertise. In this paper, we analyze teacher’s remarks that represent verbal behaviors and propose a new method of evaluating those remarks. It is important for teachers to explain professional knowledge consistently. We therefore analyze time-series variations of similarity between teacher’s remarks and term definitions during a lecture and examine the consistency of those remarks, based on an autocorrelation function of similarity and class evaluation questionnaires for students. We find that class evaluations tend to be higher when the autocorrelation function monotonically decreases.

Keywords: Class improvement, Class evaluation, Text mining, Time series analysis

1. Background
This paper proposes an evaluation method for teacher's verbal behavior in university classes, focusing on teacher's remarks. Our goal is to support class design that improves the manner and order of teacher's explanations. In recent years, Japanese universities have been required to make class improvements through teacher's behavior [1]. Teacher's behavior is divided into verbal and nonverbal behavior, and recently much work has been done on the nonverbal aspects. For example, one study classified nonverbal behavior regarded as assisting verbal behavior, and demonstrated improvement in the understandability of a lecture [2]. However, the experimental environment of most of these studies was primary education or education for persons with disabilities. In higher education, teachers must accurately provide expert knowledge about high-level definitions, formulas, and theorems. It is also difficult for students to obtain new knowledge from nonverbal behavior without accompanying verbal behavior, because nonverbal behavior is essentially a means of assisting verbal behavior. Therefore, it is important for teachers to improve their verbal behavior to teach new, advanced knowledge. However, few studies have directly evaluated verbal behavior, in particular teacher's remarks. One study considered a model for arranging the order of teacher's explanations to support lectures, but did not analyze of teacher's remarks [3]. In this paper, we describe the following
points:
1. Proposal of a method for arranging teacher's remarks during lectures as a time series
2. Proposal for evaluating the consistency of remarks using an autocorrelation function
3. Analysis of the relation between the consistency of remarks and class evaluations

We thus propose a method for objectively evaluating remarks during a lecture. Figure 1 shows a conversion of teacher's remarks into time-series data by term similarity.

2. Methods

2.1 Analysis objects
We analyzed lectures on information science performed in 2010–2011, whose objectives were defining technical terms such as “mapping” and “set,” and we evaluated the consistency of explanatory terms used in the lecture. Students, who were enrolled in the Faculty of Engineering, replied to 20 questions on a class evaluation questionnaire after each lecture. These were 90-min general classroom-style lectures, with the last 20 min used as exercise time.

2.2 Conversion of teacher's remarks in a lecture into time-series data
First, each teacher’s remark was converted into text with timestamps. Next, supposing one teacher’s remark as a single document, a term frequency–inverse document frequency (tf-idf)
value [4] was calculated (Table 1). Time data were recorded at this time. Finally, the cosine similarity of each remark with the tf-idf value for the terms defined in the Information Science Dictionary [5] was calculated and related to a time series of remarks (Table 2). We use the cosine resemblance degree as the calculation of the resemblance degree [6].

![Table 1: Examples of remark, order, time, and tf-idf values](image)

<table>
<thead>
<tr>
<th>Term</th>
<th>52nd</th>
<th>53rd</th>
<th>54th</th>
<th>55th</th>
<th>56th</th>
<th>57th</th>
<th>58th</th>
<th>59th</th>
<th>60th</th>
</tr>
</thead>
<tbody>
<tr>
<td>writing</td>
<td>0</td>
<td>0.477</td>
<td>0.431</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>do</td>
<td>0.209</td>
<td>0</td>
<td>0</td>
<td>0.116</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.076</td>
<td>0</td>
</tr>
<tr>
<td>print</td>
<td>0.642</td>
<td>0</td>
<td>0</td>
<td>0.179</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>follow</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.281</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>commentary</td>
<td>0</td>
<td>0</td>
<td>0.383</td>
<td>0.420</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>person</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.157</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>roughly</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.145</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.383</td>
<td>0</td>
</tr>
</tbody>
</table>

![Table 2: Time and the cosine similarity of values (excerpt)](image)

Figure 2 shows an example of time-series variation in the similarity between teacher's remarks and definitions of technical terms. In the figure, a moving average over 300-s intervals was taken to normalize the weight of each remark.
As the figure shows, the similarity for remarks on “set” tends to be higher than that for remarks on “mapping” in the first half of the lecture, and they become approximately the same level at 2,000 s, indicating that the lecture topic changed from “set” to “mapping”. To analyze such tendencies, an autocorrelation function for the time-series data was calculated and its relation with class evaluations was examined.

2.3 Proposal of evaluation for consistency in remarks by autocorrelation function

The change in teacher’s remarks was analyzed using an autocorrelation method to evaluate how consistently terms were explained in the lecture. The autocorrelation function estimates the correlation between a value and the value at time Δt, and the mode or periodicity in the change of the value is obtained [7]. It was expected that remark consistency could be evaluated for a given topic by applying the autocorrelation to the time-series similarity.

3. Results

3.1 Analysis of autocorrelation function

As an example, we calculated autocorrelation functions for two lectures and compared them (Fig. 3). In Result A, the autocorrelation function tends to decrease monotonically, suggesting that the lecture continued to be consistent. In contrast, in Result B the autocorrelation function increased again after it decayed, suggesting that the lecture lacked consistency. Namely, it is considered that the lecture was diverted to a different topic, and then resumed after that explanation was complete.
3.2 Consistency analysis based on class evaluation questionnaires

We expected that consistency in teacher’s remarks would influence class evaluations. Autocorrelation function results can be roughly classified into three types:

X: Monotonic decrease after about 300 s
Y: Monotonic decrease after about 600 s
Z: Increase following a decrease after 300 s, or continued decrease

We examined the results for the class evaluation question “Were you able to grasp the key points of the lesson?” We analyzed 19 lectures, comprising 10 lectures given in 2010 and 9 in 2011. Class evaluations used a 5-point scale, and averaged values for about 100 students in each lesson were calculated.
Consistency in teacher’s remarks could thus be estimated by using the autocorrelation of time-series similarities between remarks and term definitions. The analysis indicates that class
evaluations tend to be lower when variation in the autocorrelation function is large.

3.3 Discussion
The following summarizes the proposed methods in this paper:

1. Proposal of a method for arranging teacher's remarks during lectures as a time series
   We calculated the cosine similarity between term definitions and remarks, which could be expressed as a time series. Doing so visualizes the time when an teacher is talking about important terms.

2. Proposal for evaluation of the consistency of remarks using an autocorrelation function
   We visualized the way of making remarks and the importance of topics in a lecture as a time-series representation of the autocorrelation function for the similarity between remarks and definitions.

3. Analysis of the relation between the consistency of remarks and class evaluations
   When the autocorrelation function monotonically decreased—namely, when consistent explanations were made—class evaluations tended to be high. When autocorrelation functions frequently varied—namely, when explanations were inconsistent—class evaluations were low. We consider it important that teachers carefully determine the manner of their remarks during instructional design. These results suggest an influence of teacher's remarks on class evaluations, and the importance of remarks can be analyzed by this approach.

4. Conclusion
By focusing on verbal behavior in higher education, particularly on teacher's remarks, we proposed a method for presenting remarks as time-series data using the degree of similarity between remarks and the definitions of technical terms. As a result, we were able to visualize important lecture points as time-series data of the degree of similarity. Further, an autocorrelation function was applied to analysis of consistency in teacher's remarks, and it was related to the results of class evaluation questionnaires. The results suggested that consistent explanations result in higher class evaluations. It was possible to objectively visualize transitions in teacher's remarks in a lecture. This approach should also allow examination of the importance of scripts and the order of remarks in a lecture. However, the autocorrelation function needs further study to try various techniques of time-series analysis from the standpoint of class evaluations, and to propose new improvements to class evaluations based on this approach.

Acknowledgements
This research was supported by a Grant-in-Aid for Scientific Research (B) (# 24300291) from Japan Society for the Promotion of Science (JSPS).

5. References


7. William W. S. Wei. (2005), Time Series Analysis Univariate and Multivariate Methods, Department of Statistics The Fox School of Business and Management Temple University.
 ICEAI-1008

Minimum-Energy Trajectory Planning Based on Hamiltonian Function for a Mechatronic Motor-Table System

Kun-Yung Chen, Assistant Professor
Department of Mechanical Engineering, Air Force Institute of Technology,
chenkunying@yahoo.com.tw

Abstract
In this paper, the minimum energy control input based on Hamiltonian strategy is proposed for the motor-table system. The methods of the minimum control effort (MCE), minimum input energy control (MIEC), minimum dissipation energy control (MDEC) and trapezoidal trajectory energy control (TTEC) are compared for the motor-table system. From the numerical results, it can be found that the MIEC and MDEC approaches can obtain the same minimum input energy simultaneously. The MCE approach was regarded as the minimum energy control in the previous study. In this paper, we have demonstrated that the MIEC approach is not the minimum energy control. Finally, the energy balance equation that contains the input energy, dissipation energy, potential energy and output energy for the motor-table system is also found in this paper.

Keywords—Hamiltonian Function, Minimum Control Effort (MCE), Minimum Input Energy Control (MIEC).

1. Introduction
The theme of inadequate energy sources is currently discussed and performed by experts and researchers. According to the consumption of energy for real mechatronic system, design the minimum energy trajectories and control for all mechatronic systems are the optimal stratagem. In the previous researches, the authors had proposed the minimum energy control theory to perform the minimum energy problems [1-3]. But the definitions of input energy are not the energy physical definition. Fortunately, Kokotovic and Singh [4] had presented the minimum-energy control for a nonlinear second-order model of a ground transportation vehicle with a dc traction motor for which regenerative braking is possible. The Hamiltonian is implemented to obtain the minimum energy control input. The definition of performance index for minimum energy is the physical energy. But the author only considers the electrical problem; the complete formulation with electrical and mechanical mechatronic system problem is not performed.

Huang et al [5] propose a novel minimum-energy point-to-point (PTP) trajectory planning method for a motor-toggle servomechanism, they employed the real-coded genetic algorithm
(RGA) to search for the minimum-energy trajectory for the PTP motion profile, which is described by a polynomial with suitable conditions of position, velocity, and acceleration at the start and end points. The paper only considers the dissipation energy of the electrical resistance as fitness function and minimizes the function by the RGA. The dissipation energy of mechanism is not studied. Chen et al. [6] proposed a minimum control effort based on the simplest controller of proportional-integral-derivative (PID) controller is utilized by particle swarm optimization (PSO) approach. The control parameters of PID controller can be searched and selected by PSO to minimize the control input energy for the mass-spring-damper system. But the approach can’t be guaranteed that the results are the minimum-energy control.

In this paper, we proposed the motor-table system as the minimum energy control analytic examples. Firstly, the physical work definition of input energy is proposed including control voltage and current for this system. Therefore, the state space equations are given as a voltage control matrix form. Secondly, the energy balance equation including electrical energy and mechanism energy is found. Finally, minimum control effort (MCE), minimum input energy control (MIEC) and minimum dissipation energy control (MDEC) methods based on Hamiltonian function are proposed and compared. Moreover, the trapezoidal trajectory energy control (TTEC) also is compared in this paper.

2. Dynamic Modelling

The configuration of the motor-table system is geometrically shown in Fig. 1. The system is consisted of the permanent magnet synchronous motor (PMSM), screw and a table. The screw is a media that makes the smaller torque \( \tau \) to convert into the control input force \( f \) acting on the table. The conversion relationship is

\[
\tau = \frac{f l_d}{2\pi n}, \tag{1}
\]

where \( l_d \) is the lead of screw, \( n \) is the gear ratio number and can be described as follows:

\[
n = \frac{n_a}{n_b} = \frac{\tau_m}{\tau} = \frac{\omega}{\omega_r}, \tag{2}
\]

where \( n_a \) and \( n_b \) are the gear number, \( \tau_m \) is the output torque by motor, \( \tau \) is the control torque applied on the screw, \( \omega \) is the angular speed of the screw, \( \omega_r \) is the angular speed of the motor.

2.1 Mathematical model of PMSM

The machine model of a PMSM can be described in a rotor-rotating coordinate [5] as follows:
\[ v_d = R_d i_d + \frac{d \lambda_d}{dt} + w_s \lambda_q, \]  
\[ v_q = R_q i_q + \frac{d \lambda_q}{dt} - w_s \lambda_d, \]  
\[ \lambda_q = L_d i_d, \]  
\[ \lambda_d = L_q i_q + L_m d i_d. \]  

In the above equations, the subscripts \( d \) and \( q \) represent the \( d \) and \( q \)-axis, respectively, \( v_d \) and \( v_q \) are the stator voltages, \( i_d \) and \( i_q \) are stator currents, \( L_d \) and \( L_q \) are the armature inductances, \( \lambda_d \) and \( \lambda_q \) are the stator flux linkages, \( R_s \) and \( w_s \) are the stator resistance and inverter frequency. In Eq. (4-2), the \( i_{fd} \) is the equivalent \( d \)-axis magnetizing current, and \( L_{md} \) is the \( d \)-axis mutual inductance.

Fig. 1 The model of motor-table system.

The electric torque is:
\[ \tau_e = \frac{3}{2} p \left[ L_m d i_d i_q + (L_d - L_q) i_d i_q \right]. \]

With the implementation of field-oriented control, the electric torque can be obtained as:
\[ \tau_e = K_{\mu q}, \]
\[ K_t = \frac{3}{2} p L_m a I_{qf}, \quad (6-2) \]
\[ H_p(s) = \frac{1}{J_m s^2 + B_m}, \quad (6-3) \]

where \( p \) is the number of pole pairs, \( i_q \) is the torque current command, \( K_t \) is the motor torque constant, \( H_p(s) \) is the PM transfer function.

The applied torque can be obtained as follows:
\[
\tau = n(\tau_r - J_m \ddot{\omega}_r - B_m \omega_r) = n(K_t i_q - nJ_m \dot{\omega} - nB_m \omega), \quad (7)\]

where \( \tau \) is the load torque applied in the direction of \( \omega_r \), and the variables \( \omega_r \) and \( \dot{\omega}_r \) are the angular speed and acceleration of the rotor, respectively, \( B_m \) is the damping coefficient, and \( J_m \) is the moment of inertia.

*2.2 Completed formulation of the motor-table system*

Substituting Eq. (7) into Eq. (1), the control input force \( f \) can be rewritten as follows
\[
f = \frac{2\pi n}{L_d} \tau = \frac{2\pi n}{L_d} \left( K_t i_q - J_m \frac{2\pi n}{L_d} \dot{x} - B_m \frac{2\pi n}{L_d} \ddot{x} \right). \quad (8)\]

The force equation for the table can be written as
\[
f - c \ddot{x} = m \dddot{x}, \]

where \( c \) is the viscous coefficient, \( m \) is the mass of the table.

The Eq. (8) is substituted into Eq. (9) including mechanical and electrical equation can be given as follow

![Diagram](image)

Fig.2 The PM drive system: The block diagram of the voltage control for the motor-table system with PMSM.

\[
(m + z^2 J_m) \dddot{x} + (c + z^2 B_m) \dddot{x} = z K_t i_q, \quad (10)\]

where \( z = \frac{2\pi n}{L_d} \).
In the mechanism system, the PMSM is controlled by the voltage command $v_q$ and the control block diagram is shown in Fig. 2. From Eq. (3-1), the control input voltage can be described with the state current $i_q$ and velocity $\dot{x}$ as follows

$$v_q = R_s i_q + L_q \left( \frac{d}{dt} i_q \right) + \lambda_d \dot{x}.$$  

Finally, it is found the matrix form and described as follows:

$$X = AX + Bu = F(X, u, t),$$

where

$$X = \begin{bmatrix} x & \dot{x} & i_q \end{bmatrix}^T = \begin{bmatrix} x_1 & x_2 & x_3 \end{bmatrix}^T, \quad A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}, \quad B = \begin{bmatrix} b_1 & b_2 & b_3 \end{bmatrix}^T, \quad u = v_q,$$

$$a_{11} = 0, \quad a_{12} = 1, \quad a_{13} = 0, \quad a_{21} = 0, \quad a_{22} = \frac{c + z^2 B_m}{(m + z^2 J_m)}, \quad a_{23} = \frac{z K_i}{(m + z^2 J_m)},$$

$$a_{31} = 0, \quad a_{32} = \frac{-z \lambda_d}{L_q}, \quad a_{33} = \frac{-R_s}{L_q}, \quad b_1 = b_2 = 0, \quad \text{and} \quad b_3 = \frac{1}{L_q}.$$

3. Designing of the minimum-energy trajectory and controller

It is important to find the energy equation for the motor-table system. The mechanical equation Eq. (10) and electrical equation Eq. (11) can be found and rewritten as

$$z K_i x_3(t) = z^2 B_m x_2(t) + (m + J_m z^2) \ddot{x_2}(t),$$

$$u(t) = R x_3(t) + L_q \frac{d}{dt} x_3(t) + \lambda_d \ddot{x}_2(t).$$

The energy equation can be respectively written as

$$z K_i x_3(t) x_2(t) \Delta t = z^2 B_m x_2^2(t) \Delta t + (m + J_m z^2) \dot{x}_2(t) x_2(t) \Delta t,$$

$$u(t) x_3(t) \Delta t = R x_3^2(t) \Delta t + L_q \left( \frac{d}{dt} x_3(t) \right) x_3(t) \Delta t + \lambda_d \ddot{x}_2(t) x_3(t) \Delta t,$$

where $\Delta t$ is the sampling time.

Eq. (15-1) can be found $x_3(t)$ as

$$x_3(t) = \frac{(c + B_m z^2)}{z K_i} x_2(t) + \left( m + J_m z^2 \right) \ddot{x}_2(t).$$

Substituting Eq. (16) into Eq. (15-2) and it can be found the energy balance equation as

$$\int_0^f u(t) x_3(t) dt = \int_0^f R x_3^2(t) dt + \left( \frac{\lambda_d}{K_i} \right) \int_0^f (c + B_m z^2) x_2^2(t) dt + \int_0^f L_q \left( \frac{d}{dt} x_3(t) \right) x_3(t) dt$$

$$+ \left( \frac{\lambda_d}{K_i} \right) \int_0^f (m + J_m z^2) \ddot{x}_2(t) x_2(t) dt.$$
It is defined the input energy \( E_i(t) \), dissipation energy \( E_d(t) \), potential energy \( E_p(t) \) and output energy \( E_o(t) \) as:

\[
E_i(t) = \int_0^t u(t)x_3(t)dt, \tag{18-1}
\]

\[
E_d(t) = \int_0^t Rx_3^2(t)dt + \left( \frac{\lambda_d}{K_t} \right)^2 \int_0^t (c + B_m z^2)x_2^2(t)dt, \tag{18-2}
\]

\[
E_p(t) = \int_0^t L_q \left( \frac{dx_3(t)}{dt} \right)x_3(t)dt, \tag{18-3}
\]

\[
E_o(t) = \left( \frac{\lambda_d}{K_t} \right)^2 \int_0^t (m + J_m z^2) \dot{x}_2(t)x_2(t)dt. \tag{18-4}
\]

### 3.1 MCE

The cost function of MCE [7-8] is defined as follows:

\[
J_1(u) = \int_0^T \frac{1}{2} u^2(t)dt. \tag{19}
\]

The Hamiltonian function is given as:

\[
H_1 = \frac{1}{2} u^2(t) + p_1(t)a_{12}x_2(t) + p_2(t)[a_{22}x_2(t) + a_{23}x_3(t)] + p_3(t)[a_{32}x_2(t) + a_{33}x_3(t) + b_3 u(t)], \tag{20}
\]

where \( p_1, p_2 \) and \( p_3 \) are Lagrange multipliers.

The necessary conditions for optimality are:

\[
\dot{p}_1(t) = -\frac{\partial H_1}{\partial x_1} = 0, \tag{21-1}
\]

\[
\dot{p}_2(t) = -\frac{\partial H_1}{\partial x_2} = -a_{12} p_1(t) - a_{22} p_2(t) - a_{32} p_3(t), \tag{21-2}
\]

\[
\dot{p}_3(t) = -\frac{\partial H_1}{\partial x_3} = -a_{23} p_2(t) - a_{33} p_3(t), \tag{21-3}
\]

\[
0 = \frac{\partial H_1}{\partial u} = u^*(t) + b_3 p_3(t). \tag{21-4}
\]

If Eq. (21-4) is solved for \( u^*(t) \) and substituted into the state equations (13), it can be found:

\[
\dot{x}_1^*(t) = a_{12}x_2^*(t), \tag{22-1}
\]

\[
\dot{x}_2^*(t) = a_{21}x_1^*(t) + a_{22}x_2^*(t) + a_{23}x_3^*(t), \tag{22-2}
\]

\[
\dot{x}_3^*(t) = a_{32}x_2^*(t) + a_{33}x_3^*(t) - b_3^2 p_3^*(t). \tag{22-3}
\]
Equations (22-1)–(22-3) are the state equations, a set of $2n$ linear first-order, homogeneous, constant-coefficient differential equations. The details of $x_1^*(t)$, $x_2^*(t)$, $x_3^*(t)$ and $u^*(t)$ are written in the Appendix.

### 3.2 MIEC

We have proposed the energy equation of the system in Eq. (17) and the cost function of the minimum input energy control can be defined as follows

$$J_2(u) = \int_0^T u(t)x_3(t)dt.$$  \hspace{1cm} (23)

The augmented functional by adjoining constraint relations to $J_2(u)$, which yields

$$J_a(u) = \int_0^T \{u(t)x_3(t) + q^T(t)[F(X,u,t) - \dot{X}(t)]\}dt.$$  \hspace{1cm} (24)

Where $q = [q_1 \ q_2 \ q_3]^T$, $q_1$, $q_2$ and $q_3$ are Lagrange multipliers. The variation of the functional $J_a(u)$ can be given as

$$0 = \delta J_a(u) = -q\delta X + \int_0^T \left\{ [h_1 + \dot{q}_1 \ h_2 + \dot{q}_2 \ h_3 + \dot{q}_3] \delta X + \delta u(x_3 + b_3q_3) \right\}dt.$$  \hspace{1cm} (25)

where $h_1 = a_{11}q_1 + a_{21}q_2 + a_{31}q_3$, $h_2 = a_{12}q_1 + a_{22}q_2 + a_{32}q_3$, $h_3 = u + a_{13}q_1 + a_{23}q_2 + a_{33}q_3$.

The necessary conditions for optimality are obtained as

$$\dot{q}_1 = -a_{11}q_1 - a_{21}q_2 - a_{31}q_3, \hspace{1cm} (26-1)$$

$$\dot{q}_2 = -a_{12}q_1 - a_{22}q_2 - a_{32}q_3, \hspace{1cm} (26-2)$$

$$\dot{q}_3 = -a_{13}q_1 - a_{23}q_2 - a_{33}q_3 - u, \hspace{1cm} (26-3)$$

$$x_3 + b_3q_3 = 0. \hspace{1cm} (26-4)$$

If Eq.(26-4) is solved for $u^*$ and substituted into the state equations (13), it can be found

$$\dot{x}_1^*(t) = a_{12}x_2^*(t), \hspace{1cm} (27-1)$$

$$\dot{x}_2^*(t) = a_{21}x_1^*(t) + a_{22}x_2^*(t) + a_{23}x_3^*(t), \hspace{1cm} (27-2)$$

$$\dot{x}_3^*(t) = a_{32}x_2^*(t) + a_{33}x_3^*(t) + b_3u^*(t). \hspace{1cm} (27-3)$$

Equations (27-1)–(27-3) are the state equations, a set of $2n$ linear first-order, homogeneous, constant-coefficient differential equations. The details of $x_1^*(t)$, $x_2^*(t)$, $x_3^*(t)$ and $u^*(t)$ are solved and can be found in the Appendix.

### 3.3 MDEC
The cost function of MDEC can be defined as

\[
J_3(u) = \int_0^T \left[ Rx_3^2(t) + \left( \frac{\lambda_d}{K_t} \right)(x_2^2(t) + x_2^2(t)) \right] dt. 
\]  
(28-1)

It can be found the given equation by Eq. (17) and the cost function for MDEC can be modified as

\[
J_3(u) = \int_0^T \left[ u(t) x_2(t) - Lq \dot{x}_3(t) x_3(t) - w(m + J_m z^2) \dot{x}_2(t) x_2(t) \right] dt, 
\]  
(28-2)

where \( w = \frac{\lambda_d}{K_t} \).

The augmented functional by adjoining constraint relations to \( J_3(u) \), which yields

\[
J_6(u) = \int_0^T \left\{ u(t) x_3(t) - Lq \dot{x}_3(t) x_3(t) - w(m + J_m z^2) \dot{x}_2(t) x_2(t) + s^T(t) [\mathbf{F}(x, u, t) - \dot{x}(t)] \right\} dt. 
\]  
(29-1)

The variation of the functional \( J_6(u) \) can be given as

\[
0 = \delta J_6(u) = -[s_1 \quad (s_2 + \dot{M}x_2) \quad (s_3 + Lq \dot{x}_3)] \delta \mathbf{X} \bigg|_{t=0}^{t=T} 
\]  
\[+ \int_0^T \left[ h_1 \dot{s}_1 + h_2 s_2 + h_3 s_3 + Lq \dot{s}_3 \right] \delta \mathbf{X} + \delta u(x_3 + b_3 s_3) \]  
(29-2)

where \( s = [s_1 \quad s_2 \quad s_3]^T \), \( s_1 \), \( s_2 \) and \( s_3 \) are Lagrange multipliers and \( \dot{M} = w(m + J_m z^2) \).

The necessary conditions for optimality are obtained as

\[
s_1^* = -a_{11} s_1^* - a_{21} s_2^* - a_{31} s_3^*, \]  
(30-1)

\[
s_2^* = -a_{12} s_1^* - a_{22} s_2^* - a_{32} s_3^*, \]  
(30-2)

\[
s_3^* = -a_{13} s_1^* - a_{23} s_2^* - a_{33} s_3^* - u^*, \]  
(30-3)

\[
x_3^* + b_3 s_3^* = 0. \]  
(30-4)

From the above necessary conditions, it is found that \( s_1^*(t) = q_1^*(t) \), \( s_2^*(t) = q_2^*(t) \) and \( s_3^*(t) = q_3^*(t) \). The results of the MDEC are the same with the MIEC. Therefore, it can be summarized that the MDEC and MIEC can get the same input energy. The \( x_1^*(t) \), \( x_2^*(t) \), \( x_3^*(t) \) and \( u^*(t) \) of the MDEC are the same with MIEC.

### 3.4 TTEC

The trapezoidal trajectory is a general trajectory for trajectory planning program. The descriptions of the total displacement is \( S \), constant velocity is \( v_0 \) and constant acceleration is \( a_0 \). Therefore, the trapezoidal trajectory can be described as follow
4. Numerical simulations

In the numerical simulations, the parameters are performed and given as follows:

\[
\begin{align*}
    x_1(t) &= \frac{1}{2} a_0 t^2, \quad 0 < t \leq t_1 \\
    x_1(t) &= x_1(t_1) + v_0(t \wedge t_1), \quad t_1 < t \leq t_2 \\
    x_1(t) &= x_1(t_2) + v_0(t \wedge t_2) - \frac{1}{2} a_0(t \wedge t_2)^2, \quad t_2 < t \leq T \\
    x_2(t) &= a_0 t, \quad 0 < t \leq t_1 \\
    x_2(t) &= v_0, \quad t_1 < t \leq t_2 \\
    x_2(t) &= v_0 - a_0(t \wedge t_2), \quad t_2 < t \leq T \\
    \dot{x}_2(t) &= a_0, \quad 0 < t \leq t_1 \\
    \dot{x}_2(t) &= 0, \quad t_1 < t \leq t_2 \\
    \dot{x}_2(t) &= -a_0, \quad t_2 < t \leq T
\end{align*}
\]

Then, the current \( x_3(t) \) can be found as follows:

\[
x_3(t) = \frac{1}{a_{23}} [\dot{x}_2(t) - a_{21} x_1(t) - a_{22} x_2(t)],
\]

According to the above trajectories, the control input of the TTEC for motor-table system can be written as:

\[
u(t) = \frac{1}{b_3} \left[ \dot{x}_3(t) - a_{32} x_2(t) - a_{33} x_3(t) \right].
\]

4.1 Comparison among the MCE, MIEC and TTEC

In this numerical simulations, the input energy is the electrical input energy and the control effort is the voltage. The responses, control effort and the absolute input energy of the motor-table system are shown in Fig. 3. It is found that responses of the TTEC approach are different from the other two approaches. It is easy to recognize that the TTEC has the maximum input energy in Fig. 3 (e) and (f). But the input energy of the MCE and MIEC are very similar in Fig. 3 (e) and (f). The details of the comparisons with the approaches are listed in Table 1. It can be found the MIEC also has the minimum absolute input energy. A conclusion, the relations of the absolute control input energy (\( \sum |E_i(t)| \)) are: MIEC(902.746 J, minimum) < MCE(908.3299 J, +0.6143%) < TTEC(1032.2854 J, +14.3459% ,maximum). The input energy, dissipation energy, potential energy and output energy are compared and shown.
in Fig. 4. The TTEC has large jump responses at 0.25 s and 0.75 s, because of the trajectory of the velocity is switched at the two times. When the input energy is provided into the motor-table at every instant, the dissipation energy almost consumes all input energy at every instant that is shown in Figs. 4(a)~(b). Therefore, it can be found the resistance and viscous damper is the major energy consumption for the motor-table system.

4.2 Discussion and summary
From the numerical simulation results, the MIEC can obtain the minimum input energy and get the trajectory with the minimum input energy. The TTEC can obtain the maximum input energy. To deserve to be mentioned, the previous study had employed the MCE as the minimum energy control to perform the energy consumption problem. But from the results of this paper, the MIEC is the minimum (absolute) input energy. Why the MIEC and MDEC can obtain the same minimum input energy? From the energy equation, total input energy equals to total dissipation energy, total potential energy and total output energy. The potential energy and kinetic energy are the necessary dissipation energy for any system.

![Comparisons among the MCE, MIEC and TTEC](image-url)
Therefore, minimizing the dissipation energy also can minimize the input energy. According to the above descriptions, it can be found that the MIEC based on Hamiltonian function can obtain the minimum input energy for the motor-table system.

5. Conclusion

The Hamiltonian is employed to obtain the minimum energy trajectories and control input of the MCE and MIEC approaches. The input energy is compared for the motor-table system. In the previous studies, the researchers regard the MCE approach as the minimum energy control. But the comparison results in this paper that verifies the MCE is not the minimum energy control. However, the MIEC and MDEC approaches are obtained by the calculus of the variations Lagrange multipliers and Hamiltonian strategy. From the numerical results, we have successfully demonstrated that the trajectories and control input of the MIEC and MDEC approaches can obtain the same minimum (absolute) input energy. Furthermore, the energy equation including electrical and mechanism is proposed and it is employed to obtain the
MDEC based on Hamiltonian. In the future, the MIEC approach can be employed to other mechatronic systems to design the minimum energy trajectories that are tracked by robust controller.

Appendix

A. The details of MCE

\[ x_1^*(t) = a_1(-2.9441 \times 10^{-4})e^{166.451t} + a_2(-6.3209 \times 10^{-3})e^{35.9229t} + a_3(0.0186872 - 0.5521t) + a_4(1.5039 \times 10^{-3})e^{-166.451t} + a_5 (1.4125 \times 10^{-3})e^{-35.9229t} + a_6, \]  

\[ x_2^*(t) = a_1(-0.049)e^{166.451t} + a_2(-0.2271)e^{35.9229t} + a_3(-0.5521) + a_4(-0.2503)e^{-166.451t} + a_5(-0.05074)e^{-35.9229t}, \]  

\[ x_3^*(t) = a_1(-2.1661)e^{166.451t} + a_2(-6.4457)e^{35.9229t} + a_3(-13.2705) + a_4(-0.9682)e^{-166.451t} + a_5(-0.9987)e^{-35.9229t}. \]

where \( a_1, a_2, a_3, a_4, a_5 \) and \( a_6 \) are constants.

\[ u^*(t) = -20(a_1e^{166.451t} + a_2e^{35.9229t} + a_3). \]

The boundary conditions are \( x_1(0) = 0, \ x_2(0) = 0, \ x_3(0) = 0, \ x_1(1) = 1, \ x_2(1) = 0 \) and \( x_3(1) = 0 \). We can obtain the constants \( a_1 = -3.0982 \times 10^{-72}, \ a_2 = 1.5092 \times 10^{-15}, \ a_3 = -1.9426, \ a_4 = 1.1793, \ a_5 = 26.9563, \ a_6 = -6.0813 \times 10^{-8}. \)

B. The details of MIEC

\[ x_1^*(t) = b_1(1.78912 \times 10^{-5})e^{166.451t} + b_2(1.71925 \times 10^{-3})e^{32.923t} + b_3(1.2298 \times 10^{-5} - 6.1193 \times 10^{-4}t) + b_4(1.24747 \times 10^{-3})e^{-157.066t} + b_5(9.0074 \times 10^{-4})e^{-72.8309t} + b_6, \]  

\[ x_2^*(t) = b_1(2.97801 \times 10^{-3})e^{166.451t} + b_2(0.056603)e^{32.923t} + b_3(-6.1193 \times 10^{-4}) + b_4(-0.195935)e^{-157.066t} + b_5(-0.065602)e^{-72.8309t}. \]

\[ x_3^*(t) = b_1(0.13164)e^{166.451t} + b_2(1.58622)e^{32.923t} + b_3(-0.01471) + b_4(-0.98062)e^{-157.066t} + b_5(-0.99785)e^{-72.8309t}. \]

\[ u^*(t) = b_1(1.21541)e^{166.451t} + b_2(4.70664)e^{32.923t} + b_3(-0.02217) + b_4(1.34948)e^{-157.066t} + b_5(1.3732)e^{-72.8309t}. \]
where \( b_1 = 4.5132 \times 10^{-71} \), \( b_2 = -1.1745 \times 10^{-13} \), \( b_3 = -1.7320 \times 10^3 \), \( b_4 = -4.6769 \), \( b_5 = 30.1248 \) and \( b_6 = -1.0123 \times 10^{-7} \).

Acknowledgment
The author is grateful to the Ministry of Science and Technology for the final support under Contract No. MOST 104-2221-E-344-003

References
[5] M. S. Huang, Y. L. Hsu and R. F. Fung, “Minimum-Energy Point-to-Point Trajectory Planning for a Motor-Toggle Servomechanism,” IEEE/ASME TRANSACTIONS ON MECHATRONICS. this article has been accepted for inclusion in a future issue of this journal.
ICEAI-1053

Probe Typed Microcavity Fiber Fabry-Pérot interferometer for Simultaneously Sensing Refractive Index and Temperature

Wei-Kang Chang, Meng-Shan Wu, Chung-Hao Tseng, Cheng-Ling Lee*
Department of Electro-Optical Engineering, National United University, Miaoli 360, Taiwan
cherry@nuu.edu.tw

Abstract

We develop a novel and ultracompact fiber-optic sensor that can simultaneously measure multiple parameters of the surrounding. It is fabricated by a tip-shaped tapered-fiber-plug fused a tiny section of hollow core fiber (HCF) to be as a microcavity fiber Fabry-Pérot interferometer (MCFFPI). The MCFFPI are applied to measure the external refractive index (RI) and temperature (T) of surrounding at the same time. Experimental results show good linear responses in the RI measurement as well as the T measurement of the proposed sensing element.

Keywords: Fiber-optic component, fiber-optic sensor, microcavity fiber Fabry-Pérot interferometer (MCFFPI), tapered-fiber plug, simultaneously measurement.

1. Introduction

Probe-types of miniature Fiber Fabry–Pérot interferometers (MCFFPIs) are extremely important in the sensing applications especially for exploring many physical parameters in the dangerous environments and in the micro specimens. Several MCFFPIs with smart, simple and hybrid structures for many fields of applications on various parametric sensing have been proposed [1–6]. The MCFFPI devices can be used to measure external refractive index (RI) [1–5] and ambient temperature (T) [3–5]. The sensing characteristics of these tip typed MCFFPI sensors are generally sensitive, probed design and ultracompact. The configuration of these MCFFPIs can achieve the well known two modes interference mechanism and obtain low finesse interferometric characteristics. In addition, the sensor head of the MCFFPIs with fiber tip structures are much more convenient and ultracompact, such properties will be especially useful as a sensing probe for detecting in the harmful circumstances. In this study, a novel, ultracompact and highly sensitive pendulum-typed optical fiber simultaneously sensor that is based on a section of hollow core fiber (HCF) fused an arc-shaped tapered-fiber-plug with a flat cleaving endface to form a probe-type sensor. The basic principle of the present sensor is based on the reflective interference spectrum from the sensor tip that is changed with external RI or T from the surrounding. Experimental results show good linear responses in the RI and T measurement with the sensitivities of \(-17.66\text{dB/RIU}\) and \(0.02\text{nm/°C}\), respectively.
2. Experimental

In the fabrication, the proposed sensor was required to be monitored by an optical microscope and they are shown in the Fig. 1(a)-1(e). First of all, in the step of (a): a SMF fused with a small section of HCF, then a tapered plug is inserted into endface of the HCF as shown in Fig. 1 (b-c). In the (d) step, we spliced the junction of the taper plug and the HCF by fusion splicer for permanently fixed. Finally, cleave and remain a tiny section of taper plug in the end of the HCF. The fused taper plug is bonding strongly for the use of the sensing element, as shown in the Fig. 2 (a).

Fig. 2 (b) shows the interference mechanism of the proposed MCFFPI. The light propagates from the SMF side. When the light arrives to the HCF, little part of the light is reflected then the other is transmitted and reflected at the tip of taper fiber plug. The reflected light $r_3$ from the endface of taper fiber plug is highly influenced by the surrounding liquids. The structure will generate interference of hybrid cavities with very low finesse with composition of multiple interferences, as shown in the Fig. 3. For the theoretical analysis, it is easy to speculate the multiple interference of the proposed device by using the wave superposition. The analytical equations of the interference spectra $I(\lambda)$ are shown in the following equations Eq.(1)~Eq.(3) for the surrounding of $n_D$ (RI of liquids) > $n_{SMF}$ (RI of fiber), $n_{D}=n_{SMF}$ and $n_D > n_{SMF}$ conditions, respectively.
Here, \( r_1, r_2 \) and \( r_3 \) denote Fresnel reflections from each interface of the structure. \( n_D \) and \( n_{SMF} \) are RIs of the liquids and fiber, respectively. The \( \phi_1 \) and \( \phi_2 \) represent the phase difference caused by the cavities of air gap (\( r_1 \) and \( r_2 \) cavity) and taper fiber plug (\( r_2 \) and \( r_3 \) cavity) respectively.

\[
\begin{align*}
I(\lambda) &= r_1^2 + r_2^2 + r_3^2 - 2\sqrt{r_1^2 \cos(\phi_1) - 2\sqrt{r_2^2 \cos(\phi_2) + 2\sqrt{r_3^2 \cos(\phi_1 + \phi_2)}}} & \text{for } n_D < n_{SMF} \\
I(\lambda) &= r_1^2 + r_2^2 - 2\sqrt{r_2^2 \cos(\phi)} & \text{for } n_D = n_{SMF} \\
I(\lambda) &= r_1^2 + r_2^2 + r_3^2 - 2\sqrt{r_2^2 \cos(\phi_1) + 2\sqrt{r_3^2 \cos(\phi_2) - 2\sqrt{r_3^2 \cos(\phi_1 + \phi_2)}}} & \text{for } n_D > n_{SMF}
\end{align*}
\]

3. **Experimental Result and Discussion**

Figure 4 shows experimental setup of the measurement for obtaining the interference spectra. To investigate the RI sensing characteristics of the proposed MCFFPI as a probe-typed refractometer, a series of Cargille optical index liquids that are used for achieving the standard and precise RI measurement. During the measurement, the temperature is controlled by a TE cooler (resolution: ±0.01 °C). When a wideband light source propagates to the device, the \( r_1, r_2 \) and \( r_3 \) reflective beams from tapered plug tip and terminal junction are combined in the SMF, producing reflective interference patterns.
The main advantage of the proposed sensor is that it also can indicate the T variation of the surrounding during the RI measurement. The T measurement with environmental RI of $n_D = 1.3$ are performed and the interference spectra are shown in the Fig. 5. Experimental results show that the interference fringe shifts to long wavelength region while T increases from 26 °C to 50 °C due to the thermal expansion of the tapered plug (r2 and r3 cavity). Fig. 6(a) shows the relationship between the wavelength shift and ambient T. Experimental results display that a good linearity of response with the wavelength shift sensitivity of 0.02nm/°C can be obtained. The measured peaks of spectral fringes are shown in the inset of Fig. 6(a). Furthermore, as T increases, the surrounding liquid whose thermo-optic coefficient of $\frac{dn_D}{dT} = -3.33 \times 10^{-4} °C^{-1}$ will make its RI decreases owing to the fact that peak reflection will be increases when the T increases (RI decreases). This is because the Fresnel reflection ($r_3$) from the interface of fiber/liquid is getting higher at high T. Fig. 6(b) shows the relationship between the peak reflection and the external RI of the surrounding of the sensor. Experimental results also indicate a good linearity of response with the peak reflection with sensitivity of about $-17.66$dB/RIU. The measured peak of spectral fringes is shown in the inset of Fig. 6(b). As mentioned above, the RI variation mainly makes the changes of the interference peak power but the wavelength shifts are caused by the T varying. Therefore, we can easily distinguish the RI or T changes from the surrounding to achieve the simultaneous measurement. From the results of Fig. 5, variations of both wavelength shift and peak reflection are shown to indicate that the thermal effect affects the RI of the used optical liquid. Therefore, it is worth to mention that the sensing element can also achieve the measurement of thermal optics coefficients for the surrounding materials.
The inverse matrix can be used to simultaneously determine the variations in the refractive index \( (\Delta n_D) \) and temperature \( (\Delta T) \) of the surrounding medium by measuring the wavelength
shifts and peak power change of the interference patterns.

4. Conclusion
This study has developed and demonstrated a Fabry–Perot interferometer that can effectively utilized it to measure the variation of external refractive index and temperature. Measurements reveal that a sensitivity of −17.66dB/RIU for the peak power variation in the external RI sensing and a sensitivity of +0.02nm/°C for the wavelength shift response in the T sensing are achieved. The reported sensor is also suitable for T measurement with a good linearity response of the sensitivity of +0.02nm/°C. The experimental results have investigated the feasibility of the fiber sensor configuration to simultaneously measure the external RI and surrounding T. We anticipate the proposed sensor will have a variety of applications in optochemical and optobiological sensing fields.

5. References


ICEAI-1101
Smart Bus Transfer Computer Program

Anurak Choeichum*, Wichan Inyoo And Kanlaya Pansaen
Operation and Maintenance Department, Provincial Electricity Authority area 1 (Center), Phra Nakhon Sri Ayutthaya Province, Thailand
earth_park@hotmail.com

Abstract
This paper proposes a smart bus transfer computer program to control the operations to transfer bus load from a power transformer trips to the other healthy bus automatically and safely. The load transferring operations must comply with automatic loading control constraints. This program was used the first time in substation of Provincial Electricity Authority (PEA). The developed smart bus transfer computer program has been used in real unmanned substation in Phra Nakhon Si Ayutthaya, Thailand. Input variables for this program are various measured data obtained from Supervisory Control and Data Acquisition (SCADA). After a power outage from power transformer has been detected, the program will check many necessary data of the new network such as power status, load capacity, voltage level, relay status etc. If all constraints are satisfied, the proposed smart bus transfer computer program will transfer load to the other healthy bus adequately and automatically. This program has been developed based on SCADA System. This program was tested on the Rojana substation in Phra Nakhon Si Ayutthaya, in February 2015. Load at Rojana substation was 7 MW. It was planned to connect load to the other healthy bus. The proposed smart bus transfer computer program could detect power transformer failure and transfer bus load successfully within 59 seconds. This program will help PEA in reducing power outage duration of consumer, reducing utility worker and operation duty of operator at power station. This will enhance utility reliability, stability and organization standard.

Keywords: Power outage, Bus transfer, Transformer trip, Automation, SCADA

1. Background
Accordingly, the mission to generate, transmission and distribution of electricity to customers covered 99% of the country with improving efficiency of the supply, transmission and distribution system, THAILAND have implemented the computer-based dispatching management system or SCADA since 2004.

Eventually, Area Distribution Dispatching Center (Center 1), Phra Nakhon Si Ayutthaya province, or ADDC(C1), one of total 12 ADDCs over THAILAND, responses for 7 provinces, located in the Center of Thailand. That are Pathum Thani, Phra Nakhon Si Ayutthaya, Ang Thong, Nakhon Nayok, Prachin Buri and Sa Kaeo.
The case caused a power transformer trips or out of the system. The power supply has failed causing extensive power outage. The dispatcher must be switching load to move the load regulation of the PEA process. To restore power to the system. The transformer trips but if the transformer substation with two transformers at the power substation in the system can support a load voltage of transformer trips. We can replace the power supply of the bus that gets its power from the same transformer and converted to another transformer is left. Based on the principles of electricity and electrical engineering principles.

This proposed smart bus transfer computer program has been developed based on C language in SCADA system to supervise, detect and control automatically as the procedure of Automatic Transfer Switch (ATS). This automatic bus transfer system will help PEA in reducing power outage duration of consumer, reducing utility worker and operation duty of operator at power station. This will enhance utility reliability, stability and organization standard.

2. Methods

The dispatcher are responsible for their own performance at every stage of the review and control the device to turn the screen of the SCADA system at least three screens in operation. All equipment must be ordered to 11 times. However, the duration of power return depends on several factors such as the amount of work at the time of the ADDC, Dispatcher experience, the response of the device and the system availability. The retrospective seven years ago the event of a power outage because the transformer trips.
There are statistics that the average duration of 113 times per year in the event of a power outage caused by a transformer trips to the dispatcher to supply restored successfully is 21 minutes per session, making PEA loses the opportunity to supply an annual average of one hundred dollar (US).

![Flowchart](image)

**Fig. 3: The flow chart of this system.**

![Diagram](image)

**Fig. 4: The designed principle for the transfer program.**

The procedures and algorithms of the smart bus transfer computer program are condition-based programming described below.

In the first place, SCADA system will recognize the input signal if the initiated criteria are matched, which are:
1) Incoming breaker, connected to the power transformer is changed status from ‘close’ to ‘open’ and
2) The protective relay sends any signal from lockout contact, for example, transformer lockout,
which is determined as long-term outage. The smart bus transfer computer program which is running as background process of the SCADA system will be automatic processed. In other words, if the criteria exist and should be processed the transferring. The features, determined respectively, are:

1) The devices are available for remote control and without any tags or alarm that may cause operation failure,
2) The corresponding device statuses are within criteria, changing from closed to opened, and the status is reliable,
3) The voltage and load level, detected from metering system, is determined due to the dispatching principle. If all of the criteria are reached, this program will be processed eventually.

Then, the de-energized feeder circuit breakers are opened. After checking the successfulness for this operation, the tie circuit breaker connected to the back-up bus is closed and respectively rechecks the closed responding status to confirm to operation. Then the control command is operated. To close the feeder circuit breakers and monitor transformer demand. After that, if the program operates successfully, the information is displayed for dispatchers and logged in archive of SCADA system.

<p>| Table 1: Sequence control device |</p>
<table>
<thead>
<tr>
<th>Step</th>
<th>Device (Point)</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Auto Reclosing</td>
<td>ON &gt; OFF</td>
</tr>
<tr>
<td>2</td>
<td>Feeder Breaker (all CB)</td>
<td>CLOSE &gt; OPEN</td>
</tr>
<tr>
<td>3</td>
<td>Tie Breaker</td>
<td>OPEN &gt; CLOSE</td>
</tr>
<tr>
<td>4</td>
<td>Feeder Breaker (all CB)</td>
<td>OPEN &gt; CLOSE</td>
</tr>
<tr>
<td>5</td>
<td>Auto Reclosing</td>
<td>OFF &gt; ON</td>
</tr>
<tr>
<td>6</td>
<td>*TP FAN GROUP</td>
<td>AUTO &gt; MANUAL: ON</td>
</tr>
</tbody>
</table>

When the command signal reaches the circuit breaker but the circuit breaker, itself, is not operated. Hence, the command responding signal is not send back to ADDC. The program is set to wait fifteen seconds, after sending the last command. Then, if there is no responding status due to corresponding command, the retried command is sent. Moreover, if the second command is fail, the smart bus transfer computer program is stopped. Then the alarms are generated and logged. After that the dispatchers have to transfer load manually and call the administrator to rectify the problem.
3. Implementation

This research is divided into two types of test, the test model (Simulation) and full test (full function test) system was developed using C language. Then convert the system into SCADA (standard IEEE Std 1003.2-1992 ICS).

The real test of the accuracy of the system can be 100% accurate and exceed the expectations of the targets set for it. In the processing time and command, the system takes very good better performance than traditional about 1200 seconds.
The Criteria for the selection of the power substation to be tested are as follows.
- Select the substation ever events transformer trip.
- Select the substation with two transformers.
- Select the station included a load of up to 80% of rated power station transformers.

Usually the load for safety. To avoid damage for the power transformer. Should control power transformers rated up to 80% of each.

- Power substation with SCADA systems and equipment are available, control devices, power substations with computers and communications systems available (CSCS)

The text and acoustic alarm is generated, notified and logged for the dispatchers via the display of the SCADA system. The displayed events, logged, consist of date and time, place or substation, the current device status and the procedure for each process or event. The text alarm example is as shown in figure 6. Furthermore, the acoustic alarm is generated to display at dispatcher console when the program have started since the first step. Then if there is any error, the dispatchers are notified immediately.

![Fig. 6: The text alarm displayed on dispatchers’ console](image)

4. Conclusion

In this study, consider the many important issues such as breakers, disconnect the device from the system, then the chopper circuit breaker TIE the store each feeder. To prevent the fault in the power supply feeds the rider to monitor the loading of transformers in real time before each feeder supply. To ensure that the load is not dispatch overloading of transformers and every
judgment and order. The dispatcher will work as normal. It is safe but be quick because the computer systems times to think faster than people and continuous operation in stages. The computer system takes very little time.

According to almost one year trial period, this smart bus transfer computer program is implemented practically and correctively. Furthermore, the operation time is very short, averaged 59 seconds. Alternatively, the manually load transferring time is 21 minutes per an operation, which is not comparable. In conclusion, this bus transfer computer program will help PEA in reducing power outage duration of consumer, reducing utility worker and operation duty of operator at power station. This will enhance utility reliability, stability and organization standard.

5. Acknowledgement
The authors would like to express our thankfulness to Mr. Sakda Triyongvanich, manager of System Control and Maintenance Division, Network Operation Department, Area 1 (Center), for his fully support in this project.

6. References

J.S. Cramond, P.E., A. Carreras Jr., V.G. Duong, P.E., “Protections to Consider with Automatic Bus Transfer Scheme”, 2013.
Environmental Sciences (4)

Wednesday, May 11, 2016 14:45-16:15 Room 1006

Session Chair: Prof. Xianqiang Tang

ICCBES-1274
An Integrated Anaerobic and Aerobic System for the Bioremediation of PCE and TCE in a Simulated Groundwater Column
Chih-Hao Chang | National Chung Hsing University
Chih-Jen Lu | National Chung Hsing University

ICCBES-1292
Comparison between Normal Air and CO₂-Enriched Air for Municipal Wastewater Treatment by Chlorella Vulgaris
Ramjee Chaudhary | Indian Institute of Technology Bombay
Anil Kumar Dikshit | Indian Institute of Technology Bombay
Yen Wah Tong | National University of Singapore

ICCBES-1301
Green Electricity Production by Epipremnum aureum and Bacteria in Plant Microbial Fuel Cell
Muhd Firdaus | Universiti Teknologi Malaysia
Fateen Afikah | Universiti Teknologi Malaysia
Negar Dasineh Khiavi | Universiti Teknologi Malaysia
Norahim Ibrahim | Universiti Teknologi Malaysia

ICCBES-1304
The Design and Flow Visualization Experiment of a Self-Priming Venturi Based Nozzle to Remove the Dust Particle and Aerosols Operating in the Condition of Pool Scrubbing
C.S. Lee | Institute for Advanced Engineering
Doo Yong Lee | FNC Technology Co.
Dong-Ryul Rhim | Institute for Advanced Engineering
Junguk Shin | Institute for Advanced Engineering
Choongsub Yeum | Institute for Advanced Engineering
ICCBES-1332
Perspectives of Struvite Generation and Phosphorus Recover in Wetland Filter Beds
Xianqiang Tang | Changjiang River Scientific Research Institute

ICEAI-1191
Fiddler Crabs (Uca sp) as Ecosystem Engineer in Mangrove Area
Mulyanto Soewardi | Brawijaya University
1. Background/ Objectives

Highly chlorinated aliphatic hydrocarbons (CAHs) can not serve as the only carbon and energy source for microorganism growth. These compounds are more recalcitrant in the aerobic environment in groundwaters. Generally, highly Chlorinated aliphatics can be used as the electron acceptor accepting the electron released from the electron donor in the anaerobic reductive environment. However, in the contaminated groundwaters, this process is often limited by the lack of electron donors for reductive dechlorination. In an anaerobic environment, the main intermediate of tetrachlorethylene from the reductive dechlorination is trichloroethylene, which can be further converted to dichloroethylene, vinyl chloride, and eventually ethylene. Converting tetrachlorethylene to trichloroethylene and dichloroethylene is relatively faster in comparison with the converting dichloroethylene to ethylene in the reductive dechlorination process. Therefore, this study employed column tests to simulate a down-gradient saturated groundwater aquifer that was contaminated by dichloroethylene resulted from incompletely anaerobic decomposition of tetrachlorethylene in the up-gradient groundwater. Subsequently, this study also focused on the effect of bioaugmentation on the enhancement of reductive dechlorination of PCE.

2. Methods

The experiment was conducted with a series of sand column with volume of 735.2 mL (100.0 cm (L) × 3.0 cm (Φ) ). Each sand column contained 1.135 kg sand (dry weight). During the experimental period, the column reactors were sampled to analyze the remaining concentrations of PCE and its biodegradation intermediates with a gas chromatography (GC). The ORP and pH values were also monitored. The microbial community was analyzed with denaturing gradient gel electrophoresis (DGGE) of PCR-amplified 16S rDNA partial sequences.

3. Expected Results/ Conclusion/ Contribution

This study simulated the aerobic biodegradation of DCE and VC resulted from the incomplete anaerobic decomposition of PCE and TCE. Bioremediation was conducted by the addition of mixed aerobic bacteria that can degrade dichloroethylene in a simulated aquifer. This study
tried to investigate the aerobic biodegradation of DCE resulting from the incompletely anaerobic degradation of PCE and TCE from the up-gradient side of the simulated groundwater column. The results of the column test showed that the major intermediates present in the down-gradient side of the anaerobic sand column were DCE, VC, and methane after 14 days of operation. When mixed aerobic bacteria were added to the simulated aerobic aquifer, the removal efficiency of the intermediates (DCE and VC) generated from the anaerobic biodegradation process reached approximately 99%, indicating that the combined anaerobic and aerobic system accelerated the degradation of tetrachlorethylene and dichloroethylene. The highly chlorinated aliphatic and its degradation intermediates were almost completely biodegraded in the integrated anaerobic and aerobic simulated groundwater system.

Keywords: chlorinated aliphatic hydrocarbons, column test, combined anaerobic and aerobic system, bioremediation
Comparison between Normal Air and CO2-Enriched Air for Municipal Wastewater Treatment by Chlorella Vulgaris

Ramjee Chaudhary\textsuperscript{a,b,*}, Yen Wah Tong\textsuperscript{b,c}, Anil Kumar Dikshit\textsuperscript{a}

\textsuperscript{a}Centre for Environmental Science and Engineering, Indian Institute of Technology Bombay, Mumbai 400076, India
\textsuperscript{b}Department of Chemical and Biomolecular Engineering, National University of Singapore, Blk E5, 4 Engineering Drive 4, #03-15, Singapore 117576
\textsuperscript{c}Environmental Research Institute, National University of Singapore, Singapore
ramjeechaudhary@iitb.ac.in

Abstract

Microalgae present very good option for treatment of various kinds of wastewaters with the aim to harvest the biomass for different purposes like biogas or biodiesel production, feed supplements for animals, etc. Algae utilize organic carbon present in municipal wastewater for their metabolic growth and multiplication. In addition, these also take up nutrients such as nitrogen and phosphorus from wastewater. In the present study, axenic culture of \textit{Chlorella vulgaris} ATCC 13482 was used for treatment of primary municipal wastewater. All experiments were conducted in cylindrical glass bottles of 1 liter working volume in batch mode maintained at 25\textdegree C and 4000 lux light intensity with 14 hr/10 hr of light/dark cycle for a period of 10 days. \textit{Chlorella} inoculum was grown in municipal wastewater with supply of normal air and air enriched with 5\% CO\textsubscript{2} (vol/vol.). The aim of this study was to compare the effects of normal air and CO\textsubscript{2}-enriched air on the efficiency of wastewater treatment by the algae. The supply of 5\% CO\textsubscript{2} gave better result than that of normal air for wastewater treatment wherein COD, ammonia-N and phosphate decreased by 71\%, 94.2\% and 94.8\% respectively.

Keywords: Municipal wastewater, \textit{Chlorella vulgaris}, nutrients uptake, treatment efficiency

1. Introduction

1.1 Background

The conventional method of municipal wastewater treatment has been the aeration in activated sludge process. Hence, a major contribution to greenhouse gas emissions comes from power consumption at mechanically aerated wastewater treatment plants. Together with that, handling sludge is also a challenge for these treatment plants. During the last decade, use of algae has gained lot of importance in research because of their extensively wide applications ranging from production of protein-rich edible neutraceuticals (omega3 fatty acids) (Costa et al., 2003; Lee, 2001; Olaizola, 2003) to wastewater treatment options (Carlsson et al., 2007; Chevalier et al., 2000; Garcia et al., 2006; Guzzon et al., 2008; Woertz et al., 2009), CO\textsubscript{2} utilization (Packer,
2009; Kumar et. al, 2011) and for green energy source e.g. biodiesel, methane and ethanol (Chisti, 2007; Milledge, 2011).

1.2 Goals and objective
From the view point of measures to contain environmental pollution and resource recovery, cultivation of green algae is expected to cater to various needs: (i) algal mediated uptake of organic content and nutrients from municipal wastewater and hence, its treatment earns positive water footprint for the project (ii) bioremediation of CO$_2$ in flue gas through algal growth (production of 1 kg of algal biomass consumes nearly 2 kg of CO$_2$) (Herzog and Golomb, 2004) (iii) use of recovered O$_2$ for aerobic treatment of wastewater (1 kg of CO$_2$ utilized by algae produces nearly 0.73 kg of O$_2$ as per the stoichiometry of photosynthesis) (iv) production of biodiesel as sustainable source of eco-friendly and green fuel from lipid in algae gains carbon credits (v) use of left over algal dry mass for biogas generation under anaerobic condition. The objective of the current research work was to compare the effects of normal air and CO$_2$-enriched air on the efficiency of municipal wastewater treatment by the algae.

2. Materials and Methods
2.1 Wastewater sampling and analysis
Municipal wastewater (WW) was collected from the primary sewage tank at Water Reclamation Plant at Ulu Pandan in Singapore and stored at $4^\circ$C until further analysis. Wastewater sample was filtered through 0.45 µm filter to remove suspended particles and its characteristic parameters, given in Table 1, were estimated in triplicates (mean ± s.d.) as per Standard Methods for the Examination of Water and Wastewater (APHA, 2005). pH of wastewater sample was analyzed using Multi-Parameter Analyzer (3200M Agilent Technologies, USA). Chemical oxygen demand (COD), total-N, ammonia-N, nitrate, total-P, phosphate and sulphate were analyzed using the chemical kits and DR900 colorimeter (Hach, USA). Total inorganic carbon (TIC) and total organic carbon (TOC) were analyzed using TOC-V$_{SH}$ Analyzer (Shimadzu, Japan). Presence of few metals (Ca, K, Mg, Fe, Mn, Co, Cu and Zn) in wastewater sample necessary for growth of green algae was analyzed by ICP-OES (Perkin Elmer Optima 5300DV, USA).
2.2 Microalgae culture

Stock culture of *Chlorella vulgaris* ATCC 13482 was obtained as generous contribution from Prof. Loh Kai Chee’s lab at National University of Singapore. This microalgae species has been used for biological treatment of different kinds of wastewaters (Ji et al., 2013; Abou-Shanab et al., 2013). The algae was maintained in Bold’s Basal medium (URL) in 3-litre conical flask at 25°C and fluorescent light of 4000 lux for 14 hr/10 hr light and dark cycle and agitated at 100 rpm on magnetic stirrer. Sterile air at flow rate 0.2 vvm was bubbled through 0.2 µm filter.

2.3 Acclimatization Study

*Chlorella* grown in Bold's Basal (BB) medium for 10 days was acclimatized to municipal wastewater in cylindrical glass bottles of 2 litre working volume (inoculum to wastewater ratio as 1:20 i.e. 5% vol./vol.) before starting the treatment study. Fluorescent light of 4000 lux was supplied for 14 hr/10 hr light and dark cycle with normal air flow at 0.2 vvm. Wastewater sample was diluted with DI water in respective ratios of 30%, 60% 90% and 100% (vol./vol.) for acclimatizing algae to the wastewater. Controls with BB medium but without wastewater were also used to grow the algae. Fig.1 shows reactors for acclimatizing *Chlorella* to municipal wastewater.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.6 ± 0.05</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>293 ± 5.72</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>85.0 ± 1.31</td>
</tr>
<tr>
<td>TIC (mg/L)</td>
<td>1.5 ± 0.34</td>
</tr>
<tr>
<td>Ammonia-N (mg/L)</td>
<td>43.7 ± 1.24</td>
</tr>
<tr>
<td>Nitrate-N (mg/L)</td>
<td>1.6 ± 0.18</td>
</tr>
<tr>
<td>Total-N (mg/L)</td>
<td>46.7 ± 0.47</td>
</tr>
<tr>
<td>Orthophosphate-P (mg/L)</td>
<td>18.5 ± 0.09</td>
</tr>
<tr>
<td>Total-P (mg/L)</td>
<td>19.5 ± 0.4</td>
</tr>
<tr>
<td>Cl⁻ (mg/L)</td>
<td>117.7 ± 1.73</td>
</tr>
<tr>
<td>SO₄²⁻ (mg/L)</td>
<td>38.3 ± 1.47</td>
</tr>
<tr>
<td>Ca (mg/L)</td>
<td>16.1 ± 2.15</td>
</tr>
<tr>
<td>K (mg/L)</td>
<td>16.5 ± 0.12</td>
</tr>
<tr>
<td>Mg (mg/L)</td>
<td>4.8 ± 0.19</td>
</tr>
<tr>
<td>Fe (mg/L)</td>
<td>0.7 ± 0.02</td>
</tr>
<tr>
<td>Mn, Co, Cu, Zn (mg/L)</td>
<td>n.d.³</td>
</tr>
</tbody>
</table>

* n.d.: not detectable
As can be seen from Fig.2, *Chlorella* could adapt well even in undiluted municipal wastewater.

### 2.4 Experimental setup

Experimental setup for treatment of municipal wastewater by *Chlorella* is shown in Fig.3. Working volume of the reactors was one-liter with sterile air supply maintained at 0.2 L/min over a period of 10 days. Filtered samples of the wastewater were autoclaved at 121°C for 15 minutes before being fed into the reactors. 950 mL municipal wastewater mixed with 50 mL algae inoculum was used in each reactor. Controls (without *Chlorella*) were also used to know the evaporative loss of nutrients and COD (in case if any) by air stripping.

### 3. Results and Discussion

#### 3.1 Supply of normal air

Controls (without *Chlorella vulgaris*) showed lower removal efficiency than those with the algae (Fig.4). Alkaline condition (7 < pH range < 8.5) remained during the test period which
has been also reported in literature to be good for growth of green algae (Olaizola et al., 2004; Suryata et al., 2010). Alkaline pH also allows better capture of inorganic CO₂ into dissolved form in liquid and facilitates uptake by algae (Suryata et al., 2010). *Chlorella* showed removal efficiency of 71%, 89.2% and 90.9% for COD, ammonia and phosphate respectively.

3.2 Supply of normal air enriched with 5% CO₂

Use of 5% CO₂-laden air enhanced process of wastewater treatment by *Chlorella* with COD removal efficiency of 76.3% as shown in Fig.4 (a). With supply of 5% CO₂, it also proved to be a better choice for uptake of ammonia and phosphate removal efficiency of 94.2% and 94.8% respectively as shown in Fig.4 (c) and Fig.4 (d).

Data for decrease of organics and nutrients (COD, TOC, ammonia and phosphate) for the treatment process over 10 days have been given as summary in Table 2. Here, supply of CO₂ aids in the efficiency of the algae to treat wastewater. CO₂ utilization has been reported to enhance wastewater treatment by microalgae under mixotrophic condition (Cuellar-Bermudez et al., 2015).
For the present study, final effluent characteristics (pH, COD, TOC, ammonia and phosphate) for the treatment by Chlorella after 10 days are shown in Table 3. Values for pH, COD and phosphate are within the allowable limits for trade effluents discharge into watercourse/controlled watercourse set by Public Utilities Board Singapore (URL2).

### Table 3: Water quality of the effluent after treatment with Chlorella vulgaris

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Treatment with Chlorella using 5% CO₂</th>
<th>Discharge Standards in Singapore</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Watercourse</td>
</tr>
<tr>
<td>pH</td>
<td>8.11</td>
<td>6-9</td>
</tr>
<tr>
<td>COD (mg/L)</td>
<td>69.4</td>
<td>100</td>
</tr>
<tr>
<td>TOC (mg/L)</td>
<td>18.7</td>
<td>**</td>
</tr>
<tr>
<td>Ammonia (mg/L)</td>
<td>2.52</td>
<td>**</td>
</tr>
<tr>
<td>Phosphate (mg/L)</td>
<td>0.97</td>
<td>5</td>
</tr>
</tbody>
</table>

**not shown**

4. Conclusion

Microalgae have shown tremendous potentials in treating wastewater from different sources. Algae utilize nutrients available in the wastewater through metabolic assimilation and hence it is possible to remove and recover nutrients in form of algal biomass from wastewater. Growing microalgae with wastewater is one of the best options as control strategy for wastewater management along with CO₂ utilization. For the present study, only 5% vol./vol. algae inoculum was used and 95% vol./vol. was primary sewage municipal wastewater. Primary
sewage was efficiently treated by *Chlorella vulgaris* and the process was enhanced with supply of air enriched with 5% CO₂. COD, TOC and nutrients load (nitrogen and phosphorus) were significantly removed from the primary sewage. Further, algal biomass can be harvested and put to anaerobic digestion for methane production or lipids from algal biomass can be channelized into biodiesel production.

**Abbreviations**

ATCC: American Type Culture Collection  
COD: Chemical Oxygen Demand  
ICP-OES: Inductively Coupled Plasma-Optical Emission Spectroscopy  
PTFE: Polytetrafluoroethylene  
PUB: Public Utility Board Singapore  
TOC: Total Organic Carbon  
TN: Total Nitrogen  
TP: Total Phosphorus  
vvm: volume of gas supply/volume of liquid/minute (aeration rate)

**Acknowledgments**

The partial funding for this research was provided by the National Research Foundation Singapore under its Campus for Research Excellence and Technological Enterprise (CREATE) programme. The first author would also like to thank National University of Singapore for hosting him as doctoral research exchange student under joint PhD programme with Indian Institute of Technology Bombay.

5. **References**


URL1, Bold's Basal medium (http://www.ccap.ac.uk/media/documents/BB.pdf) Culture Collection of Algae and Protozoa, Dunstaffnage Marine Laboratory, Oban, Argyll, PA37 1QA, UK.

Due to high energy demand worldwide, finding an alternative renewable and sustainable energy source is of great interest. Recently, fuel cells are considered as a high potential clean energy technology, due to the high energy conversion efficiency through the chemical degradation process. Microbial fuel cells are one of the most studied fuel cells, due to its potential application to generate electricity from wastewater treatment processes. Plant microbial fuel cell (P-MFC) is one of the most promising methods to generate green energy. In P-MFC, a plant is placed into the anode compartment. The objectives of this research are to utilize *Epipremnum aureum* plant to generate electricity and observe current generation by different external loads, to characterize immobilized bacteria attached on the anode surface followed by identifying the optimum growth temperature for isolated bacteria. Mutual interaction between plant root rhizodeposits and bacterial community resulted in the biofilm formation at the vicinity of the rhizosphere area in plant root, could be utilized to generate electricity. Indeed, in P-MFC, bacteria metabolize rhizodeposits into electrons and protons. These electrons could be then converted into green electricity. In this work, *Epipremnum aureum* collected from Kota Tinggi’s lake in Johor Bahru, Malaysia was selected as the studied plant species. Oxygen from the root to rhizosphere area has high impact in the improvement of bio cathode (Chen *et al*., 2012). On the other hand, the selected plant is one of the local species that could grow easily in aquatic situation. Based on literatures, there is no available data about rhizodeposition of *Epipremnum aureum* and other similar species. Based on this, it was not possible to indicate which species is the most promising candidate for P-MFC. Five plant microbial fuel cells were constructed in a H-shape (dual- chambers) configuration in the plastic container. The anode compartments were covered with aluminum foil and were filled with Hoagland solution and graphite felt. The cathodes electrodes consist of graphite felt attached to the copper rods and were placed in the cathode chamber. Cathode compartment were filled with distilled water and phosphate buffer. PVC tubes were prepared as salt bridges containing 10% w/v agar and 1M NaCl. This salt bridge were fixed between anode and cathode compartments. The electrical circuit was completed by connecting graphite rods to the external loads with value ranging between 1kΩ and 10kΩ. The plant microbial fuel cells were kept in the greenhouse at temperature between 26-32 °C and uncontrolled humidity. Measurement of electricity generation by this specific species was conducted for consecutive 20 days. Cell voltage was measured off-line with a digital multimeter. The maximum open circuit voltage
(OCV) was measured at 195 mV. The five isolates were subjected to the Gram Staining Technique and various biochemical tests to identify the bacteria such as Catalase Test, Triple Sugar Iron Agar (TSI) Test, Simmons Citrate Agar Test, Motility Test (Motility Medium), Gelatin Test, Urease Test, Starch Hydrolysis Agar Plate, and OF (Oxidation-Fermentation) Test. By varying the external loads, maximum current generation was achieved at day 10. Even after a declining current generation plant kept growing afterward, without being lethal. Maximum current density for 20 days for P-MFC using an external resistance of (100k Ω) was 0.1 µA/cm². This results to the maximum power density of 0.85 µW/cm². Besides, fresh biomass average increased 5g after 20 days of experiments below and above ground as compared to that of the initial fresh biomass. The possible explanations for the plant growth and vitality are the condition of the plant-MFC which was simulated as similar to its natural environment light intensity and temperature for Epipremnum aureum. As a result, this condition was favorable for the plant to grow as well. The second reason is that the plant was growing in specific prepared solution (Hoagland solution), which provides all necessary micro and macro nutrients abundantly to growth. In short, it could be hypothesized that the MFC actually favors plant growth. This study has proven that green electricity and biomass can be produced simultaneously in P-MFC. Therefore, it can be concluded that the consumption of rhizodeposits by the electroactive bacteria can generate sustainable and non-destruction bioenergy as the alternative renewable energy source for the future.

Keywords: Plant-MFC, Epipremnum aureum, electricity generation, open circuit voltage, biomass, rhizodeposits
The Design and Flow Visualization Experiment of a Self-Priming Venturi Based Nozzle to Remove the Dust Particle and Aerosols Operating in the Condition of Pool Scrubbing

C.S. Lee\textsuperscript{a*,}, Dong-Ryul Rhim\textsuperscript{a}, Junguk Shin\textsuperscript{a}, Choongsub Yeum\textsuperscript{a}, Doo Yong Lee\textsuperscript{b}

\textsuperscript{a} Plant Engineering Center, Institute for Advanced Engineering, South Korea  
\textsuperscript{b} Department of Advanced Nuclear Technology and Engineering, FNC Technology Co., South Korea

sufaltus@iae.re.kr

1. Background/ Objectives and Goals

The venturi nozzle works in water is one of the most effective devices for removing dust particle and aerosols. And it is largely divided into two methods in accordance with active or passive operating. Active operating is often known as a forced feed way and the other is referred to as a self-priming mode. So, self-priming venturi nozzle operated in a particular situation cannot use the pump for the water supply must be designed so that water is suctioned into nozzle by the pressure difference between gas including dust particles and water.

2. Methods

For improving water intake, the nozzle is designed to having multi-staged water inlet holes. The numbers of hole in each stage are different and hole diameter is a very important factor.

![Fig. 1. Alternative operating regimes of venturi based nozzle\textsuperscript{1}](image)
3. Expected Results/Conclusion/Contribution

Several nozzle types have the different length from throat start point to the first stage of liquid inlet hole are tested. Also many experiment conditions are conducted via the variation of gas flowrates and water level. As a result, it was obtained the conclusion that three or more staged nozzle is superior to the others in the viewpoint of water suction and is expected to have a good performance in the efficiency of filtering.

Keywords: Aerosol, Dust particle, Pool scrubbing, Self Priming, Nozzle

Acknowledgements

This work was supported by the Nuclear Research & Development of the Korea Institute of Energy Technology and Planning(KETEP) grant funded by the Korea government Ministry of Trade, Industry and Energy. (No.20141510101680)

References

ICCBES-1332
Perspectives of Struvite Generation and Phosphorus Recover in Wetland Filter Beds

Xianqiang Tang
Key Lab of Basin Water Resource and Eco-Environmental Science in Hubei Province;
Changjiang River Scientific Research Institute, China
ckyshj@126.com

1. Background/Objectives and Goals
Phosphorus discharge unbearably impacts on environmental systems, and leads to significantly resource loss. It is necessary to change traditional phosphorus “removal” to phosphorus “recover”.

2. Methods
Based on characteristics analysis of phosphorus recover techniques including struvite crystallization and wetland media adsorption, novel phosphorus recover craft and procedures are developed involved in wetland beds packed with magnesium slag, which aimed to reduce the dependence of magnesium chemical reagent addition, and improved the accumulation and recover rate of struvite, and resource utilization efficiency of phosphorus saturated wetlands media.

3. Expected Results/ Conclusions/ Contribution
The proposed phosphorus recover technology is free of secondary pollution and solid waste generation, and accumulated struvite and phosphorus saturated wetlands media can be directly used as fertilizer. It is regarded as a promising solution to overcome the disadvantageous of phosphorus recovers via struvite crystallization and wetlands phosphorus adsorption.

Key words: struvite; adsorption; filter bed.
ICEAI-1191
Fiddler Crabs (Uca sp) as Ecosystem Engineer in Mangrove Area

Mulyanto, S
Fisheries and Marine Science Faculty, Brawijaya University, Malang
ciguatera.234@gmail.com

Abstract
Research has been done in Ketapang mangrove area of Probolinggo city in months of September-November 2015. The objectives are to observe the fiddler crab community structure and to analyze the effects of fiddler crabs on C/N ratio and redox potential of soil in mangrove ecosystems. The samples of fiddler crabs were taken during the low tides at 4 station (20 transects with sizes of 1 m²). Data of the fiddler crabs were measured from the soil digging inside the transect. The soil samples were taken from these crab holes wall (at the surface and at the depth of 20 cm), under the holes at the depth of 40 cm as well as from the locations that undwells by these animals at the same depth. The fiddler crab identified are U. Triangularis between 2–6 ind/m², U paradussumieri 1–3 ind/m², U perplexa 14–32 ind/m², U dussumieri 12–27 ind/m² and U. Tetragonon 3–6 ind/m². The diversity is moderate (H = 1.7) and the dominance index was low (C= 0.37). C/N ratio soil were inhabited by fiddler crab between 6–14, the undwelled area were 14–20. Soil C/N ratio was inhabited by the fiddler crab at the surface and depth of 20 cm in average of 9 cm while at 40 cm in average of 12. The low of C/N ratio at surface and depth of 20 cm causing the organic matter turnover faster because the high nitorgen content. Soil potential redox (Eh) the undwelled areas was found –0.647 mV, meanwhile the soil Eh in the dwelled areas was positive (0.68 till 0.87 mV). This mean, the decpmposition was occured during aerobic condition and will produce untotoxic substances.

Key words: fiddler crab, C/N ratio, redox potential
Biological Sciences (1)

Wednesday, May 11, 2016  14:45-16:15  Room 1007

Session Chair: Prof. Dedi Ruswandi

ICCBES-1207
Squalene Monooxygenase Plays Crucial Role on Meat-Quality Traits of Berkshire Pigs
Chul Wook Kim | Gyeongnam National University of Science & Technology
Seul Gi Kwon | Gyeongnam National University of Science & Technology
Jung Hye Hwang | Gyeongnam National University of Science & Technology
Da Hye Park | Gyeongnam National University of Science & Technology
Tae Wan Kim | Gyeongnam National University of Science & Technology
Deok Gyeong Kang | Gyeongnam National University of Science & Technology
Il-Suk Kim | Gyeongnam National University of Science & Technology
Jae Young Kim | Gyeongnam National University of Science & Technology
Sam Woong Kim | Gyeongnam National University of Science & Technology
Jung Seok Choi | Gyeongnam National University of Science & Technology
Eun Mi Lee | Gyeongnam National University of Science & Technology
Jeongim Ha | Gyeongnam National University of Science & Technology
Hwa Chun Park | Dasan Pig Breeding Co.
ICCBES-1326
Novel Identification of Reproduction Associated-Differentially Expressed Genes Correlated with Differential Methylation in Pig
Jeongim Ha | Gyeongnam National University of Science & Technology
Eun Mi Lee | Gyeongnam National University of Science & Technology
Jung Hye Hwang | Gyeongnam National University of Science & Technology
Eun-Jung Kim | Gyeongnam National University of Science & Technology
Seul Gi Kwon | Gyeongnam National University of Science & Technology
Da Hye Park | Gyeongnam National University of Science & Technology
Tae Wan Kim | Gyeongnam National University of Science & Technology
Deok Gyeong Kang | Gyeongnam National University of Science & Technology
Jae Young Kim | Gyeongnam National University of Science & Technology
Sam Woong Kim | Gyeongnam National University of Science & Technology
Jung Seok Choi | Gyeongnam National University of Science & Technology
Il-Suk Kim | Gyeongnam National University of Science & Technology
Chul Wook Kim | Gyeongnam National University of Science & Technology

ICCBES-1179
Molecular Analysis of Indonesia Maize Inbred based on SSR Markers
Dedi Ruswandi | Padjadjaran University
Budi Waluyo | Brawijaya University
Yuyun Yuwariah | Padjadjaran University
Edy Suryadi | Padjadjaran University

ICCBES-1286
Removal of Pb(II) ions by glycine-functionalized magnetic nanoparticles entrapped calcium alginate beads
Surendra Prasad | The University of the South Pacific, Suva, Fiji
Masafumi Yoshida | Tokyo City University
Kinuko Nihara | Tokyo City University
Shio Murakami | Tokyo City University

ICCBES-1209
Indole-3-Acetic Acid-Induced Phenotypic Plasticity in the Green Alga Desmodesmus
Tan-Ya Chung | National Changhua University of Education
Jhih-Yan Kuo | National Changhua University of Education
Jui-Yu Chou | National Changhua University of Education
ICCBES-1210
The Influence of Environmental Factors on the Pattern of Mitochondrial Inheritance in Yeast Hybrids
Yu-Yi Hsu | National Changhua University of Education
Jui-Yu Chou | National Changhua University of Education
ICCBES-1207
Squalene Monooxygenase Plays Crucial Role on Meat-Quality Traits of Berkshire Pigs

Chul Wook Kim1*, Seul Gi Kwon1, Jung Hye Hwang1, Da Hye Park1, Tae Wan Kim1, Deok Gyeong Kang1, Il-Suk Kim1, Hwa Chun Park2, Jae Young Kim1, Sam Woong Kim1, Jung Seok Choi1, Eun Mi Lee1, Jeongim Ha1
1Swine Science and Technology Center, Gyeongnam National University of Science & Technology, Jinju, South Korea.
2Dasan Pig Breeding Co., Namwon, South Korea
cwkim@gnTech.ac.kr

1. Background/ Research goals/ Objectives
Squalene monooxygenase (SM) converts squalene to lanosterol, a 30-carbon linear isoprenoid to tetracyclic compound. The first step of generating cholesterol is catalyzed by SM which is bound to the endoplasmic reticulum in association with NADPH-cytochrome P450 reductase, its electron transfer partner. Although its important role of SM on cholesterol generation, which is also considerable issue for many pork consumers about their diet and health, there has not been fully elucidated the role of SM on meat quality in pigs yet. In this study, we identified the SNP in SM gene and the relation between genotype in SM gene and meat quality traits. Furthermore, we also demonstrated that the role of SM on myogenesis and adipogenesis which might be important regulators of meat quality in pigs.

2. Methods
A total of 434 Berkshire pigs reared under the same conditions were used in this study. The pigs were slaughtered at a body weight of 110 kg (Dasan Genetics, Namwon, Korea) and the longissimus dorsi muscle tissues were examined various meat quality traits. The isolated mRNA from liver tissue was used for RNA-seq to identify single nucleotide polymorphisms (SNPs). The genomic DNA from logissimus dorsi muscle tissues were performed genotyping of SM gene by VeraCode GoldenGate assay method. To investigate mRNA expression of SM according to genotype, RT-qPCR was performed with mRNA from four different pigs with each genotype. C2C12 and 3T3L-1 cells were used to elucidate the role of SM on myogenesis and adipogenesis respectively. RT-qPCR was performed with primers encoding specific genes associated with adipogenesis, myogenesis and carbonylation from the cells transfected with SM siRNA.

3. Results/Conclusions
To analyze the association between SNPs and meat quality traits has been widely investigated and used for application of pig breeding to enhance economic traits of pigs as livestock. In the
present study, we identified SNP (Chr4:g14339386, C>A) within SM gene. The SNP was revealed as synonymous SNP which could not change amino acid. We performed meat quality traits and genotype in SM gene from 486 Berkshire pigs to reveal relevant associations between meat quality traits and genotype in SM gene. We have shown that meat quality traits such as backfat thickness, carcass weight, post-mortem temperature, post-mortem pH and water holding capacity were significant difference according to genotype in SM gene. Next, we examined SM mRNA expression by RT-qPCR with different genotypes in SM gene. The mRNA expression level of CC genotype was shown to be higher than AA and AC genotypes. Since amount of muscle and fat including intra-muscular fat contribute both meat quality and quantity, we performed myogenesis and adipogenesis experiment in vitro with C2C12 and 3T3-L1 cell line to speculate the role of SM in meat quality traits. As results, cells transfected with SM siRNA were down-regulated in both the myogenesis and adipogenesis compared with those with control siRNA. We additionally performed the mRNA expression of ROS scavengers such as superoxide dismutase (SOD), catalase and glutathione peroxide (GPX). Since protein oxidation is an innovative topic of increasing interest among meat science, carbonylation is generally recognized as one of the most remarkable chemical modifications in oxidized proteins. Recent studies also highlight the potential impact of specific protein carbonyls in particular meat quality traits such as water holding capacity which was shown to have significant association with genotype in SM gene in the present study. The mRNA expression of SOD, catalase and GPX was significantly decreased in SM knockdown cells compared with control cells.

In conclusion, we identify SNP in SM gene (Chr4:14339386, C>A) which has close relationship between genotype in SM gene and meat quality traits.

Key words:Squalene monooxygenase, meat quality, Berkshire pig, myogenesis, adipogenesis, SNP
ICCBES-1326

Novel Identification of Reproduction Associated-Differentially Expressed Genes Correlated with Differential Methylation in Pig

Jeongim Ha a*, Eun Mi Lee a*, Jung Hye Hwang a, Eun-Jung Kim a, Seul Gi Kwon a, Da Hye Park a, Tae Wan Kim a, Deok Gyeong Kang a, Jae Young Kim a, Sam Woong Kim a, Jung Seok Choi a, Il-Suk Kim a, and Chul Wook Kim a†

a Swine Science and Technology Center, Gyeongnam National University of Science & Technology, Jinju 660-758, South Korea
cwkim@gntech.ac.kr

1. Background/ Objectives and Goals
DNA methylation is an important epigenetic modification and regulates gene expression resulting on the livestock phenotype such as disease, milk production and reproduction. While function of several genes related to prolificacy of pig has been reported, epigenetic studies of major genes involved in litter size with porcine placenta are rare. The purpose of this study is to elucidate reproduction associated-differentially methylated regions (R-DMRs) which might regulate correlated gene expression in pig placenta.

2. Methods
In this study, 2 groups of Berkshire pigs are classified in according to litter size and breeding value; larger litter size group (LLG) and smaller litter size group (SLG). The whole-genome bisulfite sequencing (WGBS) and RNA-sequencing were performed from placenta genomic DNA and mRNA to identify R-DMRs and reproduction associated-differentially expressed genes (R-DEGs), respectively.

3. Expected Results/ Conclusion/ Contribution
Methylation levels of CpG dinucleotides in different genomic regions were shown noticeably different while global methylation pattern was similar between two groups. Analysis of DMRs revealed total 5850 of DMRs; 850 of DMRs were hyper-methylated and 5001 of DMRs were hypo-methylated in LLG compared to SLG. The distributions of DMRs in different genomic regions were examined and the majority of R-DMRs were found in coding sequence (CDS), intron and intergenic regions. Next, we analyzed R-DEGs by RNA-Seq. Total 588 of DEGs were identified; 490 genes were down-regulated and 98 genes were up-regulated in LLG compared to the SLG. Finally, the correlation of between R-DMR containing genes and R-DEGs was analyzed. As a result, 7 of R-DMRs related R-DEGs were elucidated, which are F10, PCK1, CLCA4, PRKG2, SLC45A4, ABP1, COL18A1, EPS8L3 and SLC6A19. These genes exhibited a positive correlation between methylation and expression except F10. Together, these results will provide a useful insight as molecular markers for selection of more
reproductive activity in pig.

Keywords: prolificacy, pig, placenta, methylation, DMR, DEG
ICCBES-1179

Molecular Analysis of Indonesia Maize Inbred based on SSR Markers

D. Ruswandi1*, B. Waluyo2, E. Suryadi3, and Yuyun Yuwariah1

1Faculty of Agriculture, Padjadjaran University, Bandung 40600, Indonesia;
2Faculty of Agriculture, Brawijaya University;
3Faculty of Agriculture Engineering, Padjadjaran University
dediruswandi2000@unpad.ac.id

The information on germplasm diversity among elite breeding materials is an important parameter in maize breeding. Molecular analysis of 48 Indonesia elite maize lines were analyzed using fifteen SSRs markers. Genetic relationship was determined using Jaccard’s similarity coefficient, and dendogram was then constructed based on the unweighted pair-group method with arithmetical averages (UPGMA). Result showed that (i) SSRs loci were informative for describing the genotypic variation as showed by their PIC, which ranged from 0.57 to 0.94; (ii) the forty eight maize inbred lines were clustered into three major group that corresponds well with the breeding method to apply in development of the populations, and (iii) thus, SSRs marker system is a valuable marker for genetic diversity study of Indonesian maize breeding materials.

Key words: Indonesian core collection, genetic diversity, maize, SSR

Introduction

The advance of plant breeding program is determined by genetic variability among elite genetic materials (Mukhtar et al., 2002). The information on diversity and genetic relatedness among genetic materials is critical in maize breeding. Molecular marker, such as simple sequence repeats (SSR) marker could accurately determine genetic variability and select parental lines for making new potential hybrids by reducing huge number of crosses combination as reported in maize (Revilla et al., 2002; Wang et al., 2002); rice (Xu et al., 2002); and wheat (Corbellini, et al., 2002).

He et al., 2003 explained that molecular marker is an effective tool for selection of important agronomic traits due to their accuracy in determining superior plant genotypes and free of environmental variation. Markers can detect the presence of important alleles in selected genotypes; therefore it will reduce time and money spending for selection. For the reasons of cost and simplicity, reliability, reproducibility, discrimination, and standardization, plant breeders often use SSRs or microsatellite markers (Smith et al., 1997). We molecularly analyze 48 Indonesia elite maize lines using fifteen SSRs markers to study diversity among elite breeding materials.
Materials and Methods

Forty eight Indonesia maize genotypes including 20 DR lines and 28 mutant DR were isolated their DNA for genotyping using the SSR marker. Maize leaves samples were isolated following Hoisington et al. (1997). Concentrations of DNA samples were estimated after gel electrophoresis by comparing DNA quantity with known DNA standard markers.

Fifteen primers were used to amplify DNA of DR and mutant DR lines. They were 20 mer oligo-nucleotides from commercially available primers such as: phi112, phi113, phi036, bngl126, bngl131, and bngl589. The polymerase chain reactions (PCR) were performed using optimum amplification conditions. Amplification reactions used 10µL reaction mix-containing 1x PCR buffer, 1.5 mM MgCl₂, 0.16 mM dNTPs, 0.4 mM each forward and reverse primer, 1U Taq polymerase and 20 ng of genomic DNA. Amplification profile were: one cycle for 1 min at 93°C (initial denaturation), 30 cycles for 1 min at 93°C (denaturation), 2 min 56°C/58°C/60°C (annealing) and 2 min at 72°C (extension), followed by 1 cycle of 5 min 72°C for final extension.

The PCR products were run on polyacrylamide gel in 1x TBE at 70-75 W for 45 min. The gel was stained in Promega silver stain solution. Polymorphic loci were scored as present or absent for diversity analysis. The bivariate 1-0 data were used to estimate polymorphism information content (PIC) and genetic similarity on the basis of the number of shared amplification product. The PIC was estimated based on the formula by Smith et al. (1997):

\[ \text{PIC} = 1 - \sum (p_i^2) \]

where \( p_i^2 \) is the frequency of the \( i^{th} \) allele out of the total number of alleles at an SSR locus.

The genetic similarity was estimated following Rohlf (2000):

\[ S = m / (n + u) \]

where \( m \) is the number of similar alleles; \( n \) is the total number of allele; and \( u \) is the number of non similar allele.

Genetic relationship among inbred lines were evaluated with phylogenetic trees constructed by the unweighted pair group method average (UPGMA) based on Jaccard coefficient using NTSYS-pc software version 2.1 (Rohlf,2000). Bootstrap analysis using winboot program was also conducted to estimate the level of significance of the phylogenetic trees.
Results and Discussion

Major allele, allele number, gene diversity and PIC of line, mutant and line-mutant population based on SSR markers is presented in Table 1.

<table>
<thead>
<tr>
<th>Population</th>
<th>Marker Frequency</th>
<th>Sample Size</th>
<th>Allele No.</th>
<th>Gene Diversity</th>
<th>PIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Line</td>
<td>112</td>
<td>0.45</td>
<td>20</td>
<td>6.00</td>
<td>0.71</td>
</tr>
<tr>
<td>Line</td>
<td>113</td>
<td>0.50</td>
<td>20</td>
<td>4.00</td>
<td>0.64</td>
</tr>
<tr>
<td>Line</td>
<td>36</td>
<td>0.20</td>
<td>20</td>
<td>10.00</td>
<td>0.87</td>
</tr>
<tr>
<td>Line</td>
<td>589</td>
<td>0.50</td>
<td>20</td>
<td>6.00</td>
<td>0.70</td>
</tr>
<tr>
<td>Line</td>
<td>131</td>
<td>0.15</td>
<td>20</td>
<td>14.00</td>
<td>0.92</td>
</tr>
<tr>
<td>Line</td>
<td>126</td>
<td>0.25</td>
<td>20</td>
<td>8.00</td>
<td>0.83</td>
</tr>
<tr>
<td>Mean of Line</td>
<td></td>
<td>0.34</td>
<td>20</td>
<td>8.00</td>
<td>0.77</td>
</tr>
<tr>
<td>Mutant</td>
<td>112</td>
<td>0.29</td>
<td>28</td>
<td>9.00</td>
<td>0.84</td>
</tr>
<tr>
<td>Mutant</td>
<td>113</td>
<td>0.71</td>
<td>28</td>
<td>4.00</td>
<td>0.46</td>
</tr>
<tr>
<td>Mutant</td>
<td>36</td>
<td>0.18</td>
<td>28</td>
<td>14.00</td>
<td>0.90</td>
</tr>
<tr>
<td>Mutant</td>
<td>589</td>
<td>0.25</td>
<td>28</td>
<td>8.00</td>
<td>0.85</td>
</tr>
<tr>
<td>Mutant</td>
<td>131</td>
<td>0.11</td>
<td>28</td>
<td>20.00</td>
<td>0.94</td>
</tr>
<tr>
<td>Mutant</td>
<td>126</td>
<td>0.14</td>
<td>28</td>
<td>13.00</td>
<td>0.91</td>
</tr>
<tr>
<td>Mean of Mutant</td>
<td></td>
<td>0.28</td>
<td>28</td>
<td>11.33</td>
<td>0.81</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>112</td>
<td>0.19</td>
<td>48</td>
<td>13.00</td>
<td>0.89</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>113</td>
<td>0.42</td>
<td>48</td>
<td>7.00</td>
<td>0.75</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>36</td>
<td>0.17</td>
<td>48</td>
<td>20.00</td>
<td>0.92</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>589</td>
<td>0.21</td>
<td>48</td>
<td>13.00</td>
<td>0.88</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>131</td>
<td>0.13</td>
<td>48</td>
<td>27.00</td>
<td>0.95</td>
</tr>
<tr>
<td>Line-Mutant</td>
<td>126</td>
<td>0.17</td>
<td>48</td>
<td>19.00</td>
<td>0.92</td>
</tr>
<tr>
<td>Mean of Line-Mutant</td>
<td></td>
<td>0.21</td>
<td>48</td>
<td>16.50</td>
<td>0.88</td>
</tr>
</tbody>
</table>

SSR markers detected major allele frequency of 0.15 to 0.5 and its allele number of 4-14 on line population. Thus, this population is diverse as shown by its gene diversity of 0.64-0.92 and polymorphic index coefficient (PIC) of 0.57-0.91 (Table 1).

Amplification of SSR on mutant population showed similar result in which major allele frequency ranging from 0.11-0.71 with its allele number of 4-20. Gene diversity of the mutant was 0.46-0.94 and PIC of 0.43-0.94 indicating of high diversity of the population (Table 1).

For the line-mutant population, SSR marker detected major allele frequency of 0.13 to 0.42 and its allele number of 7-27. Thus, SSR detected gene diversity of 0.75-0.95 and polymorphic
index coefficient (PIC) of 0.72-0.94 (Table 1). Based on the above results, it is shown that mutant is more diverse than their original line population.

PIC estimated the discriminatory power of any locus by considering the frequency and the number of alleles per locus in the population indicating gene diversity of population (Rongwen et al., 1995; Lopez-Sese et al., 2002). Ruswandi et al. (2005) explained that not all SSRs markers having high number of alleles could result on high PIC. SSRs marker phi109275, which has five alleles and a PIC at 0.64 had less discriminatory locus than phi076 that revealed three alleles at 0.72. Smith et al. (1997) illustrated that a marker locus that revealing five alleles, but where one allele is found in very high frequency had overall less discriminatory capability than a locus that also has five alleles, but in which those alleles are found in more frequencies.

Line population was divided into 3 groups based on genetic distance using shared- allele distance matrix on 20 Indonesian maize lines. They are 10 new genotypes derived from crossing between downy mildew resistant (DMR) lines and QPM lines (DR #1-10), 5 genotype derived from selection of DMR lines (DR # 11-15), and 5 genotype originated from selection of QPM lines (DR #16-20). This grouping is similar to the NJ analysis in which each group was clustered following DMR or QPM traits.

Genetic distance of line population ranged from 0.01 to 0.25 with the average of 0.10 (Figure 2). This indicates that there are high similarities as well as high differences among lines in the population. The similarities of the lines are supported by the coefficient of co-phenetic correlation between genetic distance and allele frequency based on their shared allele matrix of 0.93. This means that allele frequency and genetic distance is closely associated and the grouping is genetically fit.

Mutant population was divided into 7 groups (Figure 1). The position of the mutant was randomly distributed not following the original line where they come from. This means that mutation randomly change the gene and the position of the mutation is unpredictable. Fortunately the mutant can be genotypically characterized and can be determined their superiority.

Genetic distance of mutant population ranged from 0.00 to 0.19 with the average of 0.06 (Figure 2). This indicates that there are high similarities as well as high differences among mutant in the same group. Coefficient of co-phenetic correlation between genetic distance and allele frequency based on their shared allele matrix of 0.90 showed similarities of the mutant.
From the whole analysis of line-mutant analysis, there are three position of line-mutant grouping, i.e.: line, mutan, and line-mutant. This shows that there are genetic differentiation based on SSR marker. The difference grouping between line population and mutant population indicated new genetic constitution in the mutant. On contrary, the mutant-line grouping showed that mutation does not extremily change the whole genetic constitution. Thus, mutation randomly change genetic constitution of the line and express new traits.

Conclusions
SSRs loci were informative for describing the genotypic variation as showed by their PIC, which ranged from 0.57 to 0.94. The forty-eight Indonesia maize breeding materials were clustered into three major groups that correspond well with the breeding method to apply in development of the populations. Thus, SSRs marker system is a valuable marker for genetic diversity study of Indonesian maize breeding materials

Acknowledgement
The authors would like to put into words their appreciation to the Directorate General Higher Education, Ministry of Culture and Education, Republic Indonesia and Universitas Padjadjaran for the research funding through Penelitian Unggulan Perguruan Tinggi and Kompetnesi Grant (Hibah PUPT dan HIKOM) 2016 No. 021/SP2/LT/DRPM/II/2016 to the 1st author and Academic Leadership Grant 2016 to the last author.

References

ICCBES-1286

Removal of Pb(II) ions by glycine-functionalized magnetic nanoparticles entrapped calcium alginate beads

Surendra Prasad*1, Masafumi Yoshida2, Kinuko Nihara2 and Shio Murakami2

1 School of Biological and Chemical Sciences, Faculty of Science, Technology and Environment, The University of the South Pacific, Suva, Fiji
E. mail: prasad_su@usp.ac.fj

2Department of Natural Sciences, Faculty of Knowledge Engineering, Tokyo City University, Tokyo 158-8557, Japan

Abstract

The magnetic Fe3O4 nanoparticles were functionalized with glycine at pH 6. The glycine functionalized magnetic nanoparticles (GFMNPS) were then entrapped into alginate polymer as beads and used as adsorbent for the removal of Pb(II) ions. The developed adsorbents were characterized by fourier transform infrared spectroscopy, vibrating sample magnetometer and scanning electron microscopic analysis. The surface of beads contains amino and carboxylate groups which make them effective adsorbent for the removal of Pb(II) ions. The adsorption of Pb(II) ions from aqueous solution was found to be highly pH dependent. The kinetic data fitted well with pseudo second order model and the equilibrium reached in 100 min with 99.8% removal of Pb(II) ions from aqueous solution. The adsorption isotherm strictly followed Langmuir model with the maximum adsorption capacity of 555.5 mg/g of the adsorbent. The thermodynamic study confirmed that the adsorption was spontaneous and endothermic in nature. The adsorbent could be regenerated four times simply by 0.2 M HNO3 retaining 90% of the adsorption capacity. The synthesized adsorbent was found to be eco-friendly, cost effective, efficient and superior over other polymer based adsorbents for removal of Pb(II) ions from aqueous solution.

Keywords: Magnetic nanoparticles; Functionalization of nanoparticles; Calcium alginate beads; Pb(II) adsorption; Pb(II) removal.
Indole-3-Acetic Acid-Induced Phenotypic Plasticity in the Green Alga Desmodesmus

Tan-Ya Chung, Jyy-Ian Kuo and Jui-Yu Chou*
Department of Biology, National Changhua University of Education, Changhua 500, Taiwan
dan800212@gmail.com

Abstract
Phenotypic plasticity is the capacity of a single genotype to exhibit variable phenotypes in response to environmental selection pressures. The ability to adapt to multiple environments is very important for the evolutionary success of organisms. Plastic changes in organisms’ phenotypes can result from either abiotic or biotic factors. In this study, we found that the plant hormone indole-3-acetic acid (IAA) could exert stimulatory and inhibitory effects on the growth of the green alga Desmodesmus. Furthermore, we found that the morphology of Desmodesmus monocultures changed drastically under exposure to IAA. The mean number of cells per particle of Desmodesmus cultures was decreased with increasing IAA concentration. The IAA-induced unicellular populations also accumulated more oil containing lipid bodies than that in the control groups. These results suggested that the evolutionary outcome of IAA in coenobial Desmodesmus may act as phenotypic plasticity inducers to help microalgae survive in the volatile environment.

Key words: coenobia · Desmodesmus · indole-3-acetic acid · microalgae · phenotypic plasticity
ICCBES-1210
The Influence of Environmental Factors on the Pattern of Mitochondrial Inheritance in Yeast Hybrids

Yu-Yi Hsu, Jui-Yu Chou*
Department of Biology, National Changhua University of Education, Changhua 500, Taiwan
yuyi1158@gmail.com

Abstract
Mitochondria play a critical role in the generation of metabolic energy and are critical for cell survival and proliferation in eukaryotic cells. The mitochondrion is an organelle that has its own DNA. In the majority of sexual eukaryotes, the mitochondrial DNA (mtDNA) is inherited from only one parent. The mtDNA is inherited in Non-Mendelian patterns that is different from the nuclear DNA. The model organism, Saccharomyces cerevisiae is commonly used to study mitochondrial biology. It has two mating types, MAT a and MAT α. Previous studies have shown that mtDNA inheritance patterns in hybrid cells depend on the genetic background of parental strains. However, the underlying mechanisms remain unclear. To elucidate the molecular mechanisms, we examined the effects of environmental factors on the patterns of mtDNA inheritance in hybrids crossed by S. cerevisiae with S. paradoxus. The results showed that the hybrids progeny with S. cerevisiae mtDNA genotype are predominant in the medium with 5% YPD or 0.5M NaCl. In contrast, those with S. paradoxus mtDNA genotype are predominant in medium if the glycerol is the only carbon source. However, our results also show that the inheritance patterns are strain dependent. One possibility for biased mtDNA transmission in hybrids at different environments is that there are fitness differences between the hybrids carrying different mtDNA genotypes. Thus, we will use fitness competition assay to investigate this possibility in the future.

Keywords: hybrid, mitochondrial DNA, Non-Mendelian inheritance, yeast
Computer Science (2)

Wednesday, May 11, 2016 16:30-18:00 Room 1006

Session Chair: Prof. Yin-Fu Huang

ICEAI-1030
Evaluations of a Subject Knowledge Search Application based on the Aggregated Search Framework
I-Chin Wu | Fu-Jen Catholic University
Yen-Chun Huang | Fu-Jen Catholic University

ICEAI-959
Review on Classification and Time Series Prediction Methods
Najmeh Sadat Jaddi | National University of Malaysia
Salwani Abdullah | National University of Malaysia

ICEAI-1014
A New Security Design Concept Based on the Authentication Protocol and Anti-Collision Algorithm in RFID System
Chuan-Gang Liu | Chia-Nan University of Pharmacy and Science
Yu-Min Huo | National Cheng Kung University
Jung-Shian Li | National Cheng Kung University
Wei-Li Huang | National Cheng Kung University
I-Hsien Liu | National Cheng Kung University

ICEAI-1126
First Language Recognition of Spoken English Using Audio Features
Yin-Fu Huang | National Yunlin University of Science and Technology
Wei-Sheng Wang | National Yunlin University of Science and Technology

ICEAI-954
A New Scheme to Increase the Address Space of IPv4
Snajay Kumar | Pandit Ravishankar Shukla University
ICEAI-1208
Real-Time Transcoding and Cloud Resource Allocation of Adaptive Multimedia Stream System for Multiple Channels and Multiple Users
Hui-Kai Su | National Formosa University
Cheng-Shong Wu | National Chung Cheng University
Chang-Ming Lee | National Chung Cheng University
Yun-Ying Zeng | National Chung Cheng University
Yan-Sun Chu | National Chung Cheng University
Ching-Lung Chang | National Yunlin University of Science and Technology

ICEAI-1149
Identification of Disease on Leaf Soybean Image Using Learning Vector Quantization
Candra Dewi | University of Brawijaya
Muhammad Sa’idul Umam | University of Brawijaya
Imam Cholissodin | University of Brawijaya
ICEAI-1030
Evaluations of a Subject Knowledge Search Application based on the Aggregated Search Framework

I-Chin Wu*, Yen-Chun Huang
Department of Information Management, Fu-Jen Catholic University, Taiwan
icwu.fju@gmail.com

1. Background/ Objectives and Goals
Combining and assembling different search results to achieve better focus and better organization is a challenging research issue of aggregated search. The goal of aggregated search is to assemble useful and relevant information from one or multiple sources and then present it via one interface rather than presenting it as a ranked list. In our study, we aim to develop the presented WikiMap# application based on the extended generic framework of the aggregated search. We therefore propose an extended framework based on the aggregated search system. We conduct a user study to evaluate the aggregated search interface for a specific topic based on the program theory evaluation and extended evaluation measures. Finally, we adopt the maximal repeat patterns (MRPs) metric and the suffix tree algorithm in the symbolic time-series analysis field to mine and analyze sequences of search move patterns made by searchers. In this way, we aim to find the best sequences of search move patterns that lead to successful searches.

2. Methods
Aggregated search is a general term for cross-vertical aggregated search (cvAS), whose aim is the retrieval of different types of useful information or topics from multiple sources, which are then assembled into a unitary interface. Basically, research on aggregated search has taken three main directions: source (vertical) selection; result aggregation and presentation; and interest and evaluation. In this research, we focus on a proposed framework based on the concepts of the aggregated search and then conduct the evaluations. The objectives of this research are listed below.

The aggregated search framework: In our study, we aim to develop the presented WikiMap# application based on the refined generic framework of the aggregated search. Moreover, the information visualization (IV) tools to reorganize the information are presented in the proposed application.

The interface implementation and improvement: We refine one of the IV tools of the WikiMap#. Based on our previous research, the topic network is the most useful IV tool for helping users find relationships among concepts for a subject. However, it still lacks flexibility,
so we add more features to the tool. First, we add a zoom function to improve the scalability of the network. Then, we add important semantic paths of the network based on our path-mining algorithm.

Evaluations and the search move analytic algorithm: We conduct a user study to evaluate the aggregated search interface for a specific topic based on the program theory evaluation (PTE) and extended evaluation measures. In IR evaluation there are modest attempts to standardize search tasks; however, to our knowledge there are no such standardized tasks in IV that we could use in our evaluation. This work considers the goals, output, and outcome of the tools for the proposed extended evaluation measures. Finally, we adopt MRPs and the suffix tree algorithm in the symbolic time-series analysis field to mine and analyze sequences of search move patterns made by searchers.

3. Expected Results/ Conclusion/ Contribution

Assembling search results from multiple sources and then visualizing them have been an important research area for many years. In our study, we present the developed WikiMap application based on the extended generic framework of the aggregated search. We therefore propose an extended framework based on the three main components of an aggregated search system: query dispatching (QD), nuggets retrieval (NR), and result aggregation (RA). Moreover, the IV tools to reorganize the information crawled from webpages will be presented in the proposed application. We adopt the program theory evaluation (PTE) as our evaluation framework which is suitable for evaluating complex programs and can be a guideline for evaluation. The PTE investigates whether or not and how the program works, and it can provide an agenda for the next program and evaluation. The main process of PTE can be divided into four categories: inputs, activities, outputs, and outcomes. Specifically, the inputs and activities are independent variables and the outputs and outcomes are dependent variables. Our aim is to explore whether or not the assessed IV tools and multiple information provided users with improved output and outcome. The outputs are the products delivered by the search tool, and the outcomes are the benefits the search tool provides to the user. Evaluating only the outputs is insufficient to reflect the aims of the search tools and explain the search behaviors of the users. We also consider the outcomes provided by the tools of the system; in other words, the benefits searchers derive by using the tools. The goal of aggregated search is to assemble useful and relevant information from one or multiple sources and then present it via one interface rather than presenting it as a ranked list. Finally, we adopt MRPs and analyze them with the suffix tree algorithm to mine and examine sequences of search move patterns made by searchers. Our optimal goal is to develop a smart search support tool to help novices search like experts.

Keywords: Aggregated search, Extended evaluation measure, Program theory evaluation,
Search move pattern analysis
ICEAI-959

Review on Classification and Time Series Prediction Methods

Najmeh Sadat Jaddi* and Salwani Abdullah
Data Mining and Optimization Research Group (DMO), Faculty of Information Science and Technology, National University of Malaysia, Selangor, Malaysia
najmehjaddi@gmail.com

Abstract
Each of data mining techniques is provided by a set of algorithmic methods to extract the relationships in data. These techniques differ in the problems that they have ability to solve. Intelligence techniques have been used for time series prediction in recent researches. This paper presents a brief problems description which are classification and time series prediction as well as a review of the recent techniques used for these problems in the literature. Graphical summary of the methods applied for classification and time series prediction is given. Finally strengths and limitations of the methods applied are discussed.

Keyword: Classification, Intelligence techniques, Model selection, Time series prediction

1. Introduction
Data mining problems are such as: association, classification, clustering, prediction, outlier detection, regression, and visualization. The focus of this paper is a brief description of classification and time series prediction problems following by the recent techniques applied for these problems in the literature.

Classification is a task of data mining. One of the purposes of data mining is to place raw data into one of several predetermined classes. Scientifically, a class \( C_i \) \((i^{th}\text{ Class})\) is distinguished as follows:

\[
C \{o \in S | \text{Cond}(o)\},
\]

(1)

where object \( o \) is mapped from the training dataset \( S \) after assessment of the condition for \( o \) organism a member of the class \( C_i \). Simply put, classification concerns developing a model to predict the categorical names of unknown objects to differentiate between instances of different classes. This is a basic problem in data mining and is essentially a data analysis task, where a classifier is constructed to predict categorical names.

Data classification is a two-step process. In the first step, a classifier describes a determined set of data concepts. This is the training phase, where a classification algorithm learns from the
training set. In the second step, the classifier is used in the classification phase when the predictive accuracy of the classifier is measured. The accuracy of the classification of a test set of data is based on the percentage of test set tuples that are properly classified by the classifier.

Another task of data mining is time series prediction problem. A time series is a collection of observations made in sequence through time. A time series model will give forecasts of future observations that can be checked against what is really observed. Suppose we have an observed time series $x_1, x_2, ..., x_N$ and wish to forecast future values such as $x_{N+h}$. The integer $h$ is called the forecasting horizon ($h$ for horizon) and the forecast of $x_{N+h}$ made at time $N$ for $h$ steps ahead is denoted by $\hat{x}_{N+h}$, which is essentially denoted by $\hat{x}_{N}^{N+h}$ for forecasts of $x_{N+h}$.

A significant task in the preliminary examination of the data is to assess the quality of the data and consider adapting it, for example, by removing any obvious errors. There are two different strategies that can be adopted to perform long-term prediction: direct and recursive forecasts. In the case of a direct forecast strategy, in order to predict the values of a time series, $M+1$ different models are built:

$$\hat{y} (t + m) = f(y(t_1), y(t_2), ..., y(t_m))$$

with $m = 0, 1, ..., M$, where $M$ is the maximum horizon of prediction. In the case of a recursive forecast strategy, the model can be constructed by first making a one-step-ahead prediction:

$$\hat{y} (t) = f(y(t-1), y(t-2), ..., y(t-n))$$

and then predicting the next value using the same model:

$$\hat{y}(t + 1) = f(\hat{y}(t), y(t-1), y(t-2), ..., y(t-n + 1))$$

where the predicted value of $y(t)$ is used instead of the value itself, which is unknown. Then, $\hat{y}(t+1)$ to $\hat{y}(t+M)$ are predicted recursively. As mentioned, direct prediction implies the construction of different models, one for each different prediction horizon needed. Performance using this strategy is expected to be better in terms of prediction accuracy as each model is designed to predict the behaviour of the series with respect to a single horizon. However, this method has the disadvantage of needing too many models to perform long-term predictions. In addition, the understandability and usability of the model can be relatively obscure. In contrast, recursive prediction only employs one model to predict all the horizons needed. However, the main drawback of recursive prediction is that an error in the nearest horizons can be transmitted to further horizons.
2. Methods Applied to Classification and Time Series Prediction

In this section, first the techniques applied to the classification problem are discussed and then the prediction methods that can be applied to time series prediction are examined. In this review the most recent methods in the literature are highlighted and summarized to provide an overview of the techniques currently available.

2.1 Techniques Applied for Classification Problem

Classification is one of the most common learning models in data mining. Here, classification techniques are mainly categorized into the following different types: statistical learning approaches, support vector machines, fuzzy-based models, logic-based algorithms, rough-set-based models and ANNs. A summary of the methods applied in classification and related works is shown in Fig. 1.

i. Statistical learning approaches

The statistical approaches are distinguished by having an original probability model which gives a probability that an example will be in the right place in each class. One category of statistical approaches is the ‘Bayesian network’. This approach is a graphical model for the probability relation between a set of variables. A search for Bayesian network structures in the space of restricted, acyclic, partially directed graphs was presented in [1]. The researchers presented an algorithm that computes the exact posterior probability of a sub-network of the algorithm. The method proposed in [2] is based on the idea of common information and develops some well-known properties of this assess in a new way. The researchers in [3] presented a fault diagnosis system for airplane engines that employs Bayesian networks and distributed particle swarm optimisation (PSO). Another category of statistical approach is ‘instance-based learning’ which is also known as a lazy-learning algorithm [4], where the generalization process is delayed until classification is achieved. The most common method in instance-based learning is the nearest neighbour method. To overcome the weaknesses of the
k-nearest neighbour (KNN) algorithm, an integrated decremental instance-based learning algorithm was proposed in [5] with the aim of reducing storage needs, achieving better execution speed, and enhancing generalization accuracy compared with the basic nearest neighbour algorithm.

A comparison of nearest neighbour search algorithms for generic object recognition was presented in [6]. The KNN was improved by affecting the different distance functions with weights to evaluate data and then the weights for the optimisation were calculated by using a genetic algorithm (GA) in this research.

ii. Support Vector Machines

Another supervised machine learning technique is the support vector machine (SVM). This technique has been used in many research studies on the classification problem. The researchers in [7] developed a new method using SVMs. Their analysis focused on the classification of tissue samples and an investigation of the data for mislabelled tissue results. A brief review of multi-category SVMs with an emphasis on seeking ways to extend the binary SVM was provided in [8]. The theoretical basis of the SVM in regression and classification was briefly described in [9] and its application was discussed.

iii. Fuzzy-based Models

Fuzzy classification is the procedure of combining elements into a fuzzy set. In this approach, the membership function is distinct by the truth value of a fuzzy propositional function. The use of a Simulated Annealing (SA) metaheuristic to construct a fuzzy classification system was presented in [10]. The proposed algorithm works on the basis of cooperation between SA and a Subtractive Clustering (SC)-based Fuzzy Classifier (SASCFC) to solve a classification task. A general framework for designing a fuzzy rule-based classifier is presented, where the structure and parameters of the classifier are developed through a two-stage genetic search. This research proposed the OMFAM which uses SA to optimise the fuzzy set parameters associated with a modified fuzzy ant-miner (MFAM) to solve a classification problem. A revision on number of genetic-based classification rule detection methods is presented in [11].

iv. Logic Based Algorithms

The most popular logic-based algorithm approach is the ‘decision tree’. An evolutionary method was presented in [12] which permits decision tree flexibility during the use of coevolving competition between the decision tree and the training dataset. Decision trees can be transformed into a set of rules by generating a separate rule for each pathway from the root to a leaf. This strategy is known as ‘learning set of rules’. The research in [13] presented a method to handle multiclass classification in linguistic fuzzy rule-based classification systems,
where the idea is to decay the dataset into binary classification problems through the use of a pairwise learning approach.

v. **Rough Set Based Models**
A rough set was described by Pawlak [14] as a formal approximation of a crisp set. The rough set plays a role in solving the classification problem in many research studies. Two decades later, researchers proposed a classification method which is equal in terms of performance to rough-set-based classification methods but is scalable and suitable for large datasets. A research study showed that complete feature ranking followed by selection may lead to considerable reductions in data dimensionality, with major improvements in the functioning and performance of classifiers [15]. This study proposed a reformulation of the dominance principle and the introduction of second-order rough approximations to solve the drawback of imprecision in previous works, which were given in the form of intervals of possible values. In this research, authors investigated estimation methods for decision attribute values based on a variable-precision dominance-based rough set model.

In recent years, researchers around the world have been paying increasing attention to the hybridization of rough set theory and fuzzy logic. A research [16] presented a method that combines a powerful fuzzy rule induction algorithm with a rough-set-assisted feature selection method. A combined principles of rough set theory and fuzzy set theory, analyse the method that is used to resolve the uncertainty was proposed in [17]. This study showed that it is reasonable to use the degree of consistency as a critical value to decrease redundant attribute values in a database. In [18] researchers proposed a criterion in which expanded attributes are selected using the significance of fuzzy conditional attributes with respect to fuzzy decision attributes. In this study, the model explores and provides a synergistic integration of the merits of both fuzzy and rough set theory for pattern classification.

vi. **ANN Model**
Artificial neural networks are widely used for classification and rule generation. Among the vast number of ANN methods that have been used for classification, the most simple is that based on a fixed number of nodes and layers. These methods were initially based on the ‘backpropagation’ neural network. Backpropagation is a shortened version of the term ‘backward propagation of errors’. The difference between the network output and desired value is called the error value. The idea of backpropagation is to propagate the error value back to all neurons into which output values were input for the examined neuron.

Most of the previous works are based on an optimisation strategy that uses ‘metaheuristic algorithms’. A huge number of researchers have used metaheuristic algorithms in the design of ANNs to solve classification problems. Another research study [19] used a combination of
self-organising networks and an artificial immune system to minimise the neurons in an ANN. In [20] a pruned probabilistic neural network using a GA was applied to minimise the structure of an ANN. Authors in this study attempted to develop two efficient models and compared their performances in predicting the direction of movement in the daily Istanbul stock exchange. These two models are rooted in two well-known classification techniques, ANN and SVM. The researchers in [21] used the advantages of combining SA, Tabu search (TS) and backpropagation techniques to optimise an ANN. Authors in [22] used taguchi-based GA to optimise ANN model and later in [23] presented a multi-population cooperative Bat Algorithm based optimisation for ANN.

A ‘neuro-fuzzy’ model refers to the combination of an ANNs and fuzzy logic. Many researchers have used this technique to solve problems in the area of computer science. A study in [24] presented a self-adaptive neuro-fuzzy inference system that is capable of self-organising and self-adapting its structure to obtain a parsimonious rule-base for understanding the embedded information of a system from a specified training dataset. In [25] an adaptive neuro-fuzzy inference system was applied to discover the fuzzy rules in order to determine the correct class of a given input beat. While in another research an FCM-based neuro-fuzzy inference system and a GA polynomial neural network was used to establish two models in order to predict the thermal conductivity ratio of alumina (Al₂O₃)–water nanofluids.

All classification techniques have strengths and weaknesses the relative importance of which
depends on data being analysed. In this literature review the strengths and weaknesses of each technique in respect of solving the classification problem are provided to highlight the problems, limitations, and gaps in the proposed methods. Moreover, the strength and efficacy of these methods are also investigated so that their respective advantages can be leveraged in further studies.

An in-depth understanding of these methods’ strengths and limitations will enable the appropriate improvement of existing techniques in order to develop an advanced and intelligent method for solving the classification problem. The principal strengths and limitations of the classification methods in the literature are briefed in Table 1.

### 2.2 Techniques Applied for Time Series Prediction

In this section, the most recent approaches in the literature to solve the time series prediction problem are discussed. Time series prediction techniques are broadly categorized into linear and nonlinear approaches. The most recently proposed methods for both types of approach are highlighted in this section, although nonlinear models are considered the most interesting in the more recent literature. Linear approaches are categorized into exponential smoothing and autoregressive integrated moving average (ARIMA) models, while nonlinear methods are classified into regime-switching, ANNs and functional coefficient models. A summary of the methods that have been applied to time series prediction is given in Fig. 2.

![Fig. 2 A summary of methods applied for time series prediction problem](image)

#### i. Linear Models

In recent years, many researchers have used ‘exponential smoothing’ models to predict time series in different contexts. Authors in [26] presented an exponential smoothing model for air passengers prediction. The main objective of the study was to provide an expression for
forecasting that could be employed in prediction intervals for exponential smoothing methods. Then, the research in [27] provided an approach for automatic forecasting rooted in an extended range of exponential smoothing approaches. A multiplicative trend exponential smoothing approach was investigated in [28], which adapted the Holt–Winters exponential smoothing formulation so it could provide two seasonabilities. In [29] exponential smoothing models were investigated, discussed and compared in detail. A Bayesian forecasting approach for Holt’s additive exponential smoothing method was proposed in [30].

The ARIMA models have been widely used for the time series prediction problem for several years. An investigation of the application of two time series forecasting methods, logistic regression (LOGIT) and univariate ARIMA, to predict daily traffic volume for Egyptian intercity roads was reported in [31]. A research study in the context of tourism forecasting was presented in [32] that looked at forecasting methods including the AR model, the AR model using the bias-corrected bootstrap, seasonal ARIMA models, state-space models for exponential smoothing, and Harvey’s structural time series models.

**ii. Nonlinear Models**

The use of threshold (self-exiting) AR models, which are also called ‘regime-switching’ models, has been highly encouraged in [33], who describes the most basic form of this type of model, namely, piecewise linear models, which gained some attention in the literature some years ago. An evaluation of the nonlinear dynamics of stock prices with a three-regime, nonlinear threshold random walk model was presented in [34]. This study showed that long-term forecasting performance can be improved by applying nonlinear equilibrium alteration models. A study [35] attempted to provide guidelines about the use of lag length selection criteria in forming the AR lag length. Authors in [36] investigated whether or not the stock prices for Australia and New Zealand could be considered by a unit root process.

A ‘functional coefficient AR (FCAR)’ model is an AR model where the AR coefficients are permitted to differ as an assessable smooth function of another variable. A more general nonparametric approach was given in [37] that can be employed both as a first-round tool to assist in specifying an appropriate parametric model and as an independent modelling strategy. An ANN model can be effective for nonlinear processes that have an unknown functional relationship and that as a result are difficult to fit [38]. Different methods such as backpropagation have been used to address the time series prediction problem. The backpropagation strategy used for time series prediction is similar to that mentioned above in relation to classification techniques. In [39] a comparison of neural network forecasts of one-year-ahead Canadian stock returns was undertaken and the forecasts were achieved using ordinary least squares (OLS) and LOGIT methods. Backpropagation was adopted as an approach for multivariate time series prediction. Researchers in [40] proposed a method in
which the model is partially connected to a Feedforward Neural Network (FNN) from the identified input type, which refers to whether each input is joined with or separated from other inputs in producing output. In [41] a novel multiplicative seasonal ANN model was proposed as a means to improve forecasting accuracy when time series with both trend and seasonal patterns is forecast. The study revealed that there are important differences between the many different methods in the literature and the authors found that the best two methods seem to be multilayer perceptron (MLP) and Gaussian process regression. As with classification, the neuro-fuzzy approach is an area interest in the literature on time series prediction. Authors in this research examined the predictability of stock market returns by using the adaptive network-based fuzzy inference system (ANFIS). A simple and effective nonparametric method was presented in [42] for forecasting option prices derived from ANN and SVRs. An ANFIS and an ANN were compared to assess the ability of these methods to forecast the yearly overload returns of three large publicly traded companies from a time series of actual returns in [43]. The principal strengths and limitations of time series prediction methods in the literature are briefed in Table 2.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Strength</th>
<th>Limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exponential smoothing</td>
<td>• Simplicity&lt;br&gt;• Low cost&lt;br&gt;• Easy to implement&lt;br&gt;• Does not require a large amount of data</td>
<td>• Requires start-up time to find the best α&lt;br&gt;• Continuously monitoring and updating the value of α</td>
</tr>
<tr>
<td>ARIMA</td>
<td>• Can fit an approximation to almost any time series&lt;br&gt; • Ability to work with very complex distribution of objects&lt;br&gt; • Works with many parameters&lt;br&gt; • Generality&lt;br&gt; • Usefulness of nonlinearity process of neural network&lt;br&gt; • Ability to learn by instances&lt;br&gt; • Self-organising ability&lt;br&gt; • High tolerance of noisy data&lt;br&gt; • Ability to work using little knowledge of the relationships between attributes&lt;br&gt; • Capable of working with continuous values</td>
<td>• Particularly slow, especially in the training phase&lt;br&gt; • Difficult to determine the parameters of the network</td>
</tr>
<tr>
<td>ANN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Functional coefficient</td>
<td>• Robust&lt;br&gt; • Can be interpreted for unobserved data</td>
<td>• Requires very intensive data to get fully trained</td>
</tr>
<tr>
<td>Regime-switching</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Conclusion

In this paper, a brief description of classification and time series prediction problems was provided. This was followed by an extensive review of the literature in the field of classification and time series prediction. The various approaches that have been applied to solve particular problems were highlighted and discussed. A schematic summary of this review of approaches to both classification and time series prediction was given. The strengths and limitation of each technique were provided at the end of relevant subsections.
4. Acknowledgement

This work was supported by the Ministry of Education, Malaysia (ERGS/1/2013/ICT07/UKM/02/5) and Universiti Kebangsaan Malaysia (DIP-2012-15).

5. References

ICEAI-1014
A New Security Design Concept Based on the Authentication Protocol and Anti-Collision Algorithm in RFID System

Chuan-Gang Liu\textsuperscript{a*}, Yu-Min Huo\textsuperscript{b}, Wei-Li Huang\textsuperscript{b}, I-Hsien Liu\textsuperscript{b}, Jung-Shian Li\textsuperscript{b}
\textsuperscript{a} Department of applied informatics and multimedia, Chia-Nan University of Pharmacy and Science, Taiwan (R.O.C.)
\textsuperscript{b} Institute of Computer and Communication Engineering, National Cheng Kung University, Taiwan (R.O.C.)
corresponding author: chgliu@mail.cnu.edu.tw

Abstract
With the trend of IoT, Radio frequency identification (RFID) technique is getting more and more popular. The RFID system is constituted by the database, readers and tags, which the tag should pass the identification procedure of the reader via the identification data in database. During the identification process, the tag is easily exposed to an attacker due to their long sojourn time in RFID system. Usually, there are two security topics in RFID systems, which are privacy protection authentication protection and anti-collision algorithm. Recently, the researches in RFID systems catch much attention and they usually focus on one topic of them. In this paper, we try to review the papers in both study topics and discuss the new and possible security design way to develop a robust and efficiency security solution in RFID systems. The new security solution in RFID systems is to keep the tag’s private information from being revealed or tracked by any adversary when tags communicate with a reader through an unencrypted channel, usually including collision prevention and privacy protection. Our work finds the parameters and anti-collision scheme can be employed in authentication protocol in their respective scheme, which is new and novel security design and is very helpful for enhancing the security in RFID systems. Hence, in this paper, we try to discuss possible combinations of parameters in both authentication and collision prevention algorithm in a new security mechanism design. We believe this work can be an early study of new security solution design and useful in future RFID systems.

Keywords: RFID, IoT, Privacy Protection, Anti-collision, Authentication.

1. Introduction
In the decade of years, the Radio Frequency Identification (RFID) technology has been widely employed in many applications, especially in the trend of IoT. The RFID system is constituted by the database, readers and tags, which the tag should pass the identification procedure of the reader via the identification data in database. For the RFID systems, the
reader contacts with tags within its sensing range through an unencrypted channel. And the tags also respond its private ID to the reader in plaintext in the receipt of the identification command from the reader. Generally, in such RFID identification procedure, there are two common security issues in the RFID systems: how to identify RFID tags without collision and how to protect the privacy of tags. Hence, in order to achieve the first goal, a collision prevention scheme should be developed to decide to send their data in an anti-collision manner. Without a robust anti-collision scheme, many collisions occur, and the inefficiency in identification process causes RFID system unreliable.

For the existing anti-collision schemes, there are two types, aloha-based and tree-based. For the tree-based protocol, in order to avoid the collisions among tag signals, it should assign the working slot for each tag. The famous anti-collision algorithm, the adaptive binary splitting (ABS) algorithm [1], [2], makes use of the preserved identification information of the tags identified in previous time frame and allows the reader authenticates with staying tags efficiently. However, though ABS scheme can solve all the collisions among staying tags, but it still cannot prevent the collisions in a scenario which staying tags and arriving tags coexist in a given time frame. So, the following algorithms (i.e. the single resolution blocking ABS algorithm (SRB) and the pair resolution blocking ABS algorithm (PRB) [3]) improve the above problem. Basically, even if the above collision issues are resolved, some collisions still occur for the tags identified in frame $f_i$ because these tags may leave the reading range in frame $f_{i+1}$, and re-enter the reading range of the same reader in frame $f_{i+2}$. If this re-entering tag is not authenticated by any other reader, this tag may collide with the existing tags. This case is called the re-entering case. An improved anti-collision algorithm [4], the re-blocking algorithm (RBA), is therefore proposed.

The second goal of RFID system is to develop the privacy protection scheme which protects users’ privacy. Usually, in order to spread out RFID system widely, the security features of privacy protection should be included. Hence, so far, many protocols are developed to achieve privacy protection. However, the capability of the used tags decides the cost of the RFID systems and the ability of the authentication protocols. Basically, these protocols can be categorized into four classes, Full-fledged [5], Simple [6] [7], Lightweight [8] and Ultralight weight [9]. The full-fledged class authentication protocol easily achieves a private authentication, but it needs the expensive tags capable of performing the public-key encryption. Hence, it is not feasible to build a large scale RFID system. Hence, the symmetric-key protocols might be a suitable choice [6][10]. However, this kind of protocol that shared the secret parameters needs to store the preserved secret key in database. Searching the response for a given tag in the database is not quite easy while the length of the response is sufficiently long. Alomar et al. in [6], develop a protocol to trade the storing space in the database off for the efficiency of searching the secret key. The protocol in [6] allows constant-time
identification and is resilient to adversaries’ attacks. However, in [10], has point out there may be some problems when this protocol encounters Tag Compromise Attack.

According to the previous studies, the most researches in RFID systems usually focus on either collision prevention or authentication protocols. These two research issues are regarded as totally independent and rarely discussed together. In this paper, we try to discuss these two research issues at the same time and we analyze the parameters in both topics. We try to discuss possible parameter combinations and discuss the feasibility of the new security scheme. In this novel opinion, we propose a possible security solution design, which can achieve privacy protection and anti-collision features at the same time.

This paper is composed of four sections. Section 1 presents the introduction of this paper. In Section 2, we introduce some famous related works about collision prevention schemes and authentication protocol and we give the analysis of possible parameter combinations. In Section 3, we provide a novel authentication protocol combining anti-collision scheme. We conclude this paper in Section 4.

2. Discussion on two topics in RFID system
As we said previously, there are two main topics in RFID system, collision prevention and authentication protocol. Next, we review some famous scheme about two topics and discuss the possible cooperation between them.

2.1 Collision prevention schemes
Here, we mainly describe four famous collision prevention schemes, ABS, SRB, PRB and RBA. And we give the parameters used in the collision prevention schemes in Table 1.
In a collision prevention scheme, a time *frame* should be defined first, which means a time duration required by the reader to identify the tags in its sensing range. A time frame is slotted into several *slots* (or *cycles*), where a slot means the time duration which a tag can communicate with the reader. ABS is developed based on the BT approach [1], [2]. Usually, there are three
kinds of statuses for a cycle, which are Readable, Collision and Idle. Readable cycle: it means that the identification ID sent by the tag successfully is received by the reader.

Collision cycle: it means that the tags collide with each other at the same slot, which a reader will announce a collision occurring and failure of tag identification in this time.

Idle cycle: it means that there is no tag contacting the reader in this slot.

In ABS scheme, there are two counters in each tag, Allocated Slot counter (A) and Progressed Slot Counter (P). And the reader also has two counters, Terminated Slot counter (T) and Progress Slot Counter (Pc). Pc counters in the tags and the reader indicates which tag should be identified in the current frame. And Tc counter records the collision number in the identification process. A counter in tags, represents how many slots the tag should wait for contacting the reader. A counters may change their values according to different responses received from the reader. If received a Readable cycle response, tags won’t change their A counters. If received a Collision cycle response, those tags sending their IDs to the reader in the current frame will randomly increase their A counters by a binary random number (0,1), and other tags will increase their A counters by 1. With regard to the Idle cycle, all the tags that haven’t been identified will decrease their A counters by 1.

A tag which is successfully identified in frame fi will be treated as a staying tag by the reader in frame fi+1. These staying tags in fi+1 will keep their original A in fi. So there will be no collision among these staying tags in fi+1 because of the tag’s A counters has been successfully set in previous frame. But the arriving tag in fi+1 will still possibly collide with the staying tags. The whole identification process is terminated while Pc>Tc is met. An instance of ABS scheme process is as shown in Fig. 1 and Fig 2. Fig.1 shows the identification process among the reader and three tags, A, B and C in frame fi+1. And Fig.2 shows the identification process in the next frame fi+2, while a tag D arrives. We can see that the collision occurs between the arriving tag D and the staying tag A in 1st cycle of fi+1. This problem will be resolved in SRB [3]. In order to solve the collision issue between staying tags and arriving tags, SRB scheme adds a parameter, rRID, in both tags and reader. The reader and the tag compares their rRIDs, a tag knows whether it is an arriving tag or not in a frame. If the tag’s rRID is different from the reader ID, the tag should set its A counter a specific larger value to make sure not to collide with staying tags. This SRB can ensure that there is no collision occurring between the arriving tag D and the staying tags in fi+1.

Although arriving tags will not collide with the staying tag but still collide with other arriving tags. Further, a special case may occur that some arriving tags even have the same rRID with a staying tag and it will be considered as a staying tag. For example, a tag has been identified by the reader R in fi. It leave R’s range in fi+1 and come back in fi+2 without being identified by
another reader in $f_{i+1}$. In $f_{i+2}$, this tag compares its $rRID$ with the current reader’s ID and it consider itself as staying tag. It is not true. This kind of tags is defined as the re-entering tag. To prevent this collision, the RBA scheme is proposed in [4].

In order to resolve the re-entering tags collisions, the time information, i.e., frame number information, is added into tags and reader. The parameter $f_{last}$ in tags, records the frame number of the last frame that the tag is identified by a reader. The parameter, $f_{current}$ in reader, will be sent to the tags with the $rRID$ in the beginning of each frame. If the tags with the same $rRID$ and $f_{last} = f_{current} - 1$, they will be treated as the staying tags. Hence, no collision occurs between the staying tags and the re-entering tags in RBA scheme.

The detailed process of PRB and RBA is not mentioned above and the reader can refer to [3] for more details. In our paper, we focus on the study which discusses the possible new security scheme based on the anti-collision schemes and authentication protocol. In the next section 2.2, we introduce the authentication protocol.

### 2.2 Authentication protocol

Based on the capacity of the RFID tags, they can be classified into four classed: *Full-fledged*, *Simple*, *Lightweight* and *Ultralightweight* [9]. In order to widespread the use of RFID system, adjusting the tradeoff between privacy protection and the costs of tags is necessary. So, an ideal goal of developing RFID system is to achieve less cost and more privacy protection at the same time. The tags performing public-key encryption is too expensive [11]. The privacy protection scheme with the symmetric-key algorithms should be the suitable choice for the RFID systems [6]. Recently, pseudonym-based RFID authentication protocols [12-17] catch much attention. Here, we introduce a famous protocol proposed by Alomar et al. [6]. Table 2 shows the parameters used in the pseudonym-based authentication protocol.
The paper [6] allows constant-time identification and trade storage off for identification efficiency. The schematic diagram of this system is shown as Fig.3. Because we only focus on the parameters of the authentication protocol, we just show the basic authentication procedure.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$N_T$</td>
<td>The total number of tags in the system</td>
</tr>
<tr>
<td>$N_{\psi}$</td>
<td>The total number of pseudonyms in the system</td>
</tr>
<tr>
<td>$\psi_i$</td>
<td>The pseudonym of the tag</td>
</tr>
<tr>
<td>$c_i$</td>
<td>The internal cycling parameter</td>
</tr>
<tr>
<td>$C_i$</td>
<td>The maximum value of the internal cycling parameter</td>
</tr>
<tr>
<td>$h$</td>
<td>The cryptographic hash function</td>
</tr>
<tr>
<td>$\psi_{i,c}$</td>
<td>Tag’s identifier, $\psi_{i,c} = h(\psi_i, c) + h(\psi_i, c, k, r)$</td>
</tr>
<tr>
<td>$k$</td>
<td>The secret key of the tag</td>
</tr>
<tr>
<td>$f_i$</td>
<td>The $i^{th}$ frame</td>
</tr>
<tr>
<td>$U$</td>
<td>Tag update message, $U = h(\psi_i, k, \psi_{i,c}) \oplus \psi_i + h(\psi_i, k, \psi_{i,c})$</td>
</tr>
<tr>
<td>$r$</td>
<td>The random nonce included in the Authentication command</td>
</tr>
</tbody>
</table>

The schematic diagram of the pseudonym-based protocol is shown in Fig. 3.
Initially, each tag is preloaded with a unique pseudonym, \( \Psi \) and a secret key, \( k \). All values of \( h(\Psi, c) \) are stored in the database. The table of all values of \( h(\Psi, c) \) is shown in Fig. 4.

![Fig. 4 Table of all possible \( h(\Psi,c) \).](image)

With the use of this table, the reader can find out the pseudonym, \( \Psi \), and counter value, \( c \), of the current target tag in the receipt of its identifier \( \Psi_i, c \). Because each pseudonym is specified with one tag, the reader can identify the secret key of target tag and obtain \( t_2 \) sequence with the use of those information. If the calculated \( t_2 \) is correct, then the reader treats the current tag as a valid one. Then, the reader will give the tag two sequences, \( u_1 \) and \( u_2 \). In order to update the tag with the new pseudonym \( \Psi_i' \), the tag can obtain the new pseudonym from the \( u_1 \) sequence, and confirm it with the use of \( u_2 \) sequence. Once the tag finishes the update process, the authentication is completed. The more details in this protocol can refer to [6].

### 2.3 The discussion on the parameter combinations of authentication and anti-collision schemes

Based on the observation of both schemes, we can find the anti-collision scheme should execute before authentication protocol, which can ensure the connection among the reader and the tags successful. Hence, in order to combine both schemes, we try to study the possible parameters combinations between two schemes. First, we discuss the possibility of that the parameters in anti-collision scheme can be replaced with the parameters in authentication protocol. Hence, we now analyze the function of parameters in an anti-collision scheme in detail as follows.

In an anti-collision scheme, \( P_c \), \( T_c \), \( f_{current} \), and \( f_{pre} \) update automatically, which means they cannot be replaced by some specified parameters. \( rRID \) is the reader ID, which is constant and hence also cannot be changed. \( A_c \) changes its value according to the collision situations among the tags. Hence, it also cannot be assigned as an arbitrary value. Based on above analysis, we discover that anti-collision scheme should operate alone and cannot embed other parameters into its scheme. Now, we turn to discuss the parameters in authentication protocol. In an authentication protocol, secret authentication information are \( \Psi \), \( k \), \( r \), \( c \). However, we
should notice that once each connection initiate a authentication operation, $\Psi$ updates. And in order for the secret authentication, $k$, $r$ will keeps secret and fixed. Hence, only $c$ is possible parameter which can be replaced. Then, we find only $A_c$ keeps fixed after the anti-collision scheme. Hence, we try to design a new authentication protocol in RFID system based on combining $A_c$ parameter in anti-collision schemes.

3. **A new authentication protocol based on combining the parameters in anti-collision schemes**

While the tag wants to contact the reader, the first thing is the tag and the reader should negotiate with each other in order to avoid collision. Then the authentication protocol continues the following works. The whole operation of our authentication protocol is like Fig. 6 shown. In Fig. 6, the tag finishes the anti-collision scheme and sends the handle to the reader. Then, the reader extracts the handle sequence and makes the authentication command which contains not only the received handle sequence but also a random nonce $n_r$. This random nonce will change in every cycle. After receiving this authentication command, the tag will confirm if the handle’ sequence received from the reader is correct and then respond its identifier $\Phi_{t,p}$ to the reader.

$$\Phi_{t,p} = h(\Phi_{t,p}) + h(\Phi_{t,p}, k, n_r) \quad (1)$$

Here, we make use of $A_c$ in collision scheme as $p$. This parameter should own the feature which the tags and the reader can know it. Basically, $A_c$ indeed has this characteristic. Each tag should execute above basic authentication process. All possible $(\Phi_{t,p})$ are stored in the database. If the reader wants to authenticate with the tag, it should search authentication information in the database for each tag. We explain and discuss our search schemes in our novel authentication protocol.

**The search scheme for authentication information in the database**

For new arriving tags, while the reader receives the identification, $\Phi_{t,p}$, from a give tag, it will search corresponding $h(\Phi_{t,p})$ in the database. This table is as shown in Fig. 5.
If the reader find correct $h(\Phi_i, p)$, the reader can obtain the pseudonym $\Phi_i$ and the value of $A_c$ counter, $p$. The reader will check the received $h(\Phi_i, p, k, n_r)$ with the use of secret key, $k$, related with corresponding pseudonym $\Phi_i$ in the database. If the value of the received $h(\Phi_i, p, k, n_r)$ is right, the reader then confirm this authenticating tag as a valid one. After the identification of this identifier, the reader will respond the tag update message $U$ to the target tag.

$$U = h(\Phi_i, k, \Phi_i, p) \oplus \Phi_i' + h(\Phi_i', k, \Phi_i, p)$$  \hspace{1cm} (2)$$

While the tag receives this updated message, it should check if $\Phi_i'$ is correct. In order to check the correctness of $\Phi_i'$, the tag will extract from $\Phi_i'$ from $h(\Phi_i, k, \Phi_i, p) \oplus \Phi_i$ and then it uses extracted $\Phi_i'$ to check $h(\Phi_i', k, \Phi_i, p)$. If the $\Phi_i'$ in both sequences are the same, the tag confirm this authentication information and update its pseudonym and secret key by $\Phi_i'$ and $h(k)$ respectively. So far, the whole authentication completes and further, we can discover the advantage of our proposed authentication scheme. That is our search complexity is less than it in previous authentication protocol without combining anti-collision parameters. Here, we review the search complexity in previous authentication protocol. Take look at Fig. 2, if the previous authentication protocol wants to search a give $h(\Psi, c)$, it needs the search complexity $O(N_{\Psi}C)$. However, in our authentication protocol, this searching process just requires $O(N_{\Phi})$ search complexity. It is because the value of the $A_c$ counter, namely $p$, has been known by the reader before initiating the search scheme. The reason is the anti-collision executes before the authentication and hence $A_c$ has been stored in tag and the reader.
So far, we have provided our proposed novel authentication scheme which combines parameter in anti-collision scheme. We also find that our proposed authentication can achieve the authentication goal and less authentication complexity than the previous famous authentication protocol. We believe this paper provides the very novel study about the authentication protocol in RFID systems.

4. Conclusions

In this paper, we try to discuss the possibility of a new security solution in RFID systems. Hence, we review the main two security topics, anti-collision and authentication protocol. After the review of those two security topics, we discuss the possible cooperation between them and hence find the parameters in anti-collision scheme hard to be replaced. But the parameter in authentication protocol can be replaced with the use of $A_c$. Hence, in this paper, we discover a novel authentication protocol based on the parameter of collision prevention scheme. We also provide the complexity analysis between our proposed authentication protocol and previous one. Hence, a novel authentication protocol combining the collision prevention schemes is very helpful. However, this paper provides a new security design concept and provides an early work about the design the authentication protocol based on new security concept. Hence, in the future, we will continue this work and provide a more robust security analysis.

Acknowledgments

This paper was supported by the Ministry of Science and Technology of Taiwan under Grant MOST 104-2221-E-041-007 -.
References


ICEAI-1126
First Language Recognition of Spoken English Using Audio Features

Yin-Fu Huang*, Wei-Sheng Wang
Department of Computer Science and Information Engineering, National Yunlin University of Science and Technology, Taiwan
huangyf@yuntech.edu.tw

Abstract
In this paper, a speech recognition system is proposed to identify the first language of spoken English from English speaking countries and/or Non-English speaking countries. First, three kinds of audio features such as pitch, timbre, and rhythm are extracted to generate an original feature set. Then, a self-adaptive harmony search algorithm is used to select relevant features (or a local feature set) to train each one-against-one SVM classifier. Finally, a majority voting method is used to determine the first language of each speaker. Totally, 146 features are extracted from audio data, but feature selection can remove irrelevant ones more than 77%. The experimental results show that the overall accuracy for English speaking countries and Non-English speaking countries can reach 80.75% and 84.5%, respectively when using the local selection strategy.

Keywords: Speech recognition, first language recognition, feature selection, harmony search algorithm, support vector machine

1. Introduction
In recent years, more and more speech recognition systems have incorporated language based technologies. These systems including automatic language identification, gender recognition [Malhotra & Khosla, 2008; Meftah et al., 2013], age classification [Nguyen et al., 2010], emotion classification [Shen et al., 2010], and accent recognition [Bahari et al., 2013; Behravan et al, 2015; DeMarco & Cox, 2012; Li et al., 2013], have emerged as prominent research topics in speech processing. Among these systems, accent recognition further includes regional recognition [Jalalvand et al., 2012] and first language recognition [Deshpande et al., 2005].

In the existing literature, most speech recognition systems resort to extracting audio features to achieve good performances. The choices of speech analysis and modeling techniques are different based on the domain of problems under study. The successful and experienced techniques used in gender, age, and emotion recognition might not be useful for accent recognition. In general, audio features contain intensity, pitch, timbre, tonality, rhythm. For accent recognition, the most common used features are Mel-frequency cepstral coefficients (MFCCs) [Hou et al., 2010; Jalalvand et al., 2012; Nguyen et al., 2010], because MFCCs take
human perception sensitivity with respect to frequencies into consideration and are the best ones for accent recognition. Besides, formants and Root-Mean-Square (RMS) are also important features used in accent recognition [Liu & Fung, 1999; Rabiee & Setayeshi, 2010; Yusnita et al., 2011].

In this paper, we propose a speech recognition system is proposed to identify the first language of spoken English from English speaking countries and/or Non-English speaking countries where pitch, timbre, and rhythm extracted from speeches are used as original features for first language recognition. Although more audio features than past studies are considered but some of them are redundant, dimensionality reduction techniques can be employed to select relevant features in first language recognition. In general, dimensionality reduction methods can be divided into feature extraction and feature selection. The feature extraction method such as principal component analysis (PCA) [Jin & Bie, 2006] transforms the matrix of a feature set from a high-dimensional space to a lower-dimensional space through the linear combination of the matrix. On the other hand, the feature selection methods such as genetic algorithm (GA) [Lanzi, 1997], ant colony optimum (ACO) [Deriche, 2009], harmony search (HS) [Diao & Shen, 2010] find an optimum subset from an original feature set. In our work, a feature selection method called the self-adaptive harmony search (SAHS) [Huang & Wang, 2010] is employed to obtain an optimum feature subset. Finally, an SVM classifier [Chang & Lin, 2011] used in the prediction is trained using a local selection strategy.

The remainder of this paper is organized as follows. Section 2 presents the system architecture of first language recognition. In Section 3, we introduce audio characteristics and present the extracted features as an original feature set. In Section 4, the SAHS algorithm is employed to derive an optimum feature subset from the original feature set. In Section 5, we show the experimental results using different selection strategies and compare our method with the other state-of-the-art researches. Finally, we make conclusions in Section 6.

2. System Overview

In this paper, we propose a first language recognition system consisting of a training phase and a test phase, as shown in Fig. 1. In the training phase, we first extract audio features from the training set. These audio features including pitch, timbre, and rhythm are aimed to describe audio signals, 146 dimensions in total. Then, we use a meta-heuristic optimization algorithm called Self-adaptive Harmony Search (i.e., SAHS) algorithm [Huang & Wang, 2010] to select relevant features (or a local feature set) to train each one-against-one SVM classifier. For N first languages to be classified, we would have N(N-1)/2 SVM classifiers to be trained; in other words, N(N-1)/2 local feature sets should be generated to train N(N-1)/2 SVM classifiers. Finally, all the trained SVMs are combined together to form an SVM ensemble model used in the test phase.
In the test phase, we also extract the same features, as mentioned, from a test set. Then, each local feature set generated using the SAHS algorithm is fed into the corresponding one-against-one classifier in the SVM ensemble model. Finally, a majority voting strategy on $N(N-1)/2$ prediction results would determine their respective first languages of test data. The feature selection model used here enables ambiguous first languages to be classified more precisely.

3. **Feature Extraction**

Audio features are very important for first language recognition. Here, we adopt the short-term analysis on audio signals since most audio signals are stable within a short period of time. In general, audio signals can be measured in two different ways: time domain and frequency domain. For the audio features in the time domain, the samples of audio signals are directly processed along time so that we can observe some characteristics about the amplitude such as intensity and rhythm. For the frequency domain, each amplitude sample is transformed from the time domain to a corresponding frequency band in a spectrum through the discrete Fourier transform. More detailed characteristics about acoustics such as pitch, timbre, and tonality are presented by estimating the spectrum. For first language recognition, the most important features are timbre such as formants and Mel-frequency cepstral coefficients (MFCCs), and the next important ones are pitch and rhythm. In our work, we use pitch, timbre, rhythm to generate an original feature set for first language recognition. Different from the previous research, more features on timbre, which they never used in accent recognition, are considered in this paper.

3.1 **Pitch**
Pitch means the high and low frequency produced by the vibration number of a sound body such as a chord. The sound that we hear is the fundamental frequency and harmonic series. In other words, pitch is the fundamental frequency of sound; i.e., the reciprocal of the fundamental period. Here, we consider the fundamental frequency, strongest frequency via zero crossings, and strongest frequency via spectral centroid, totally 9 pitch features.

### 3.2 Timbre

Timbre is the major characteristic of sound. Even if the sounds are with the same pitch and intensity, timbre can make them distinguishable. Different timbre forms its own unique harmonic series which are multiples of the fundamental frequency, and is presented in different structures of amplitude spectrum on each or all frequency bands. By estimating the spectrum of audio signals, we can derive some timbre characteristics. Here, we consider 129 timbre features. For a frame, zero crossing counts the number of the signals crossing the zero line, spectral rolloff estimates the amount of high frequency by finding a cutoff frequency below which a certain fraction of the total energy is contained, spectral flux estimates the distance of spectrum between adjacent frames, spectral centroid estimates the centroid frequency of spectrum, spectral variability estimates the variation degree of the neighboring peaks of spectrum, harmonic spectral smoothness estimates how smooth the spectrum is through peaks, compactness is closely related to harmonic spectral smoothness but is estimated through amplitudes, and method of moments provides five statistical methods to describe the spectral shape. In addition, we also consider formants, LPC, and MFCCs described as follows.

Formants are the concept used to describe the phenomenon of acoustic resonance. Human speech and singing produce many different frequencies where formants are meaningful frequency components. Formants are measured as amplitude peaks in the frequency spectrum of the sound, using spectrogram or a spectrum analysis. Formants are usually applied in accent recognition, such as the second formant (F2) and third formant (F3) used as features in European accent recognition [Arslan & Hansen, 1997], and in Indian accent and American accent recognition [Deshpande et al., 2005]. Besides, some studies used F1 and F2 to describe the characteristics of vowels [Yusnita et al., 2011]. Here, we consider F1, F2, F3, F4, F5 as features in first language recognition.

Linear predictive coding (LPC) is a tool used mostly in audio signal processing and speech processing for representing the spectral envelope of a digital signal of speech in a compressed form, using the information of a linear predictive model. It is one of the most powerful speech analysis techniques, and one of the useful methods for encoding good quality speech at a low bit rate. Since LPC provides extremely accurate estimates of speech parameters, it is generally used for speech analysis and re-synthesis. Here, we consider 40 LPC-related features in first language recognition.
MFCCs are well-known and popular in the short-term power spectrum of sound. They are based on the known variation of human ears’ critical bandwidths with frequency. MFCCs are commonly used as features in speech recognition systems, such as the system which can automatically recognize numbers spoken in a telephone. They are also common in accent recognition, which can be used to recognize people from their voices. MFCCs can be produced from audio signals. First, an audio signal is sent to a high-pass filter as pre-emphasis. Second, using frame blocking and hamming window increase its continuity at the first and last points. Third, we perform fast Fourier transform to obtain the magnitude frequency response of each frame. Next, we multiple the magnitude frequency response by a set of 20 triangular band-pass filters to get the log energy of each triangular band-pass filter. Then, we apply discrete cosine transform on the 20 log energy obtained from the triangular band-pass filters to get L mel-scale cepstral coefficients. As a result, they have a total of 13 dimensions, including the log energy and 12 cepstral coefficients. Finally, we select 12 cepstral coefficients, and apply delta cepstrum to obtain 36 features of MFCCs.

3.3 Rhythm
Rhythm is a time-related characteristic in sounds, and consists of beats and tempos, commonly used in the music processing. In first language recognition, we only consider strongest beat and beat sum, totally 8 rhythm features.

4. Feature Selection Using SAHS
In this section, we use a feature selection algorithm called the self-adaptive harmony search algorithm [Huang and Wang, 2010] to select relevant features for facilitating first language classification. Initially, we have extracted up to 146 features as mentioned in Section 3, but not every feature is relevant for the classification. Thus, feature selection is required to improve the classification accuracy. Feature selection algorithms can be categorized into three different approaches: wrappers, filters, and embedded. Here, we use the filter approach to select relevant features since its computational loading is acceptable and the selected classification algorithm could be general.

In our work, the feature selection model consists of two parts: the self-adaptive harmony search (i.e., SAHS) algorithm and the objective function [Guiasu, 1977], as shown in Fig. 2. Once the original feature set is given, the SAHS algorithm begins to iteratively search a better solution that would be evaluated later by the objective function. Finally, the best solution will be output as the final feature subset.
5. Experimental Results

In our work, for English speaking countries such as Canada, USA, Britain, New Zealand, and Australia, we collected 400 transcribed speeches from VoxForge [http://www.voxforge.org/] that is a free speech corpus and acoustic model repository for open source speech recognition engines. On the other hand, for also 400 transcribed speeches of Non-English speaking countries such as India, Korea, Japan, China, and Taiwan, except India speeches obtained from VoxForge, the others were collected from YouTube since they are not found in VoxForge. Thus, 80 speeches from 13-20 speakers were collected for each country, and the duration of each speech is about 3-7 seconds. In the SAHS algorithm, the parameters HMS and HMCR are set with 50 and 0.99 to present the optimum performance. Next, we adopted the well-known LIBSVM developed by Chang [Chang & Lin, 2011] as an SVM classifier. The kernel function used here is Radial Basis Function since it is more accurate and effective than the other kernel ones, in general. The parameters $\gamma$ and $C$ are determined by the optimum performance of $6 \times 6$ combinations between $[2^{-4}, \ldots, 2^1]$ and $[2^{-2}, \ldots, 2^3]$. Moreover, the feature vector is normalized as the range [-1, 1]. For the classification results evaluated in ten-fold cross validation, a confusion matrix is employed to present correct and false predictions.

In this section, we would present the classification results on the original feature set. Then, by using feature selection, two strategies called global and local selection are used to present the improvement of the classification results. Finally, the comparisons between our method and the other state-of-the-art researches are presented.

5.1 Classification Results on the Original Feature Set

In this experiment, we first use fundamental frequency, formants, and MFCCs as features, totally 42 features, because they were commonly used in the past studies. The overall classification accuracy for English speaking countries is around 62.5% and the overall classification accuracy for Non-English speaking countries is around 61.5%. This result demonstrates that the features used in the past studies are not good enough in discriminating the first language. Therefore, we select more features from pitch, timbre, and rhythm, totally 146 features used as the feature vector. The classification results are illustrated in Table 1 and Table 2 where the overall classification accuracy for English speaking countries is around
74.5% and overall classification accuracy for Non-English speaking countries is around 76%. It demonstrates that some features enabling to clearly discriminate the first language have been included in the feature set.

5.2 Classification Results by the Feature Selection

Two classification results by using feature selection are presented here. First, the feature set selected based on the global selection strategy is for all 5 English or all 5 Non-English speaking countries. Then, each feature set selected based on the local selection strategy is for each pair of countries.
5.2.1 Global Selection Strategy (GSS)

In this experiment, the global feature sets for English speaking countries and Non-English speaking countries are selected, respectively. The features for English speaking countries consist of 34 features; i.e., 3 pitch and 31 timbre, whereas the features for Non-English speaking countries consist of 33 features; i.e., 3 pitch and 30 timbre. For the classification results illustrated in Table 3 and Table 4, the overall accuracy is around 78.75% and 80%, respectively and increases by 4.25% and 4% when compared with the results in Table 1 and Table 2. This result demonstrates that the feature selection model is effective to remove irrelevant features for classification and only 23% of the original features are used to get better performances, specially F2, F4, and F5 as features in first language recognition.

<table>
<thead>
<tr>
<th>First Language from</th>
<th>Canada</th>
<th>USA</th>
<th>Britain</th>
<th>New Zealand</th>
<th>Australia</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>65</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>1</td>
<td>81.25%</td>
</tr>
<tr>
<td>USA</td>
<td>6</td>
<td>60</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>75%</td>
</tr>
<tr>
<td>Britain</td>
<td>2</td>
<td>7</td>
<td>61</td>
<td>4</td>
<td>6</td>
<td>76.25%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>7</td>
<td>4</td>
<td>3</td>
<td>62</td>
<td>4</td>
<td>77.5%</td>
</tr>
<tr>
<td>Australia</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>1</td>
<td>67</td>
<td>83.75%</td>
</tr>
</tbody>
</table>

**Precision** 80.25% 80% 71.76% 79.49% 82.72% 78.75%

<table>
<thead>
<tr>
<th>First Language from</th>
<th>India</th>
<th>Korea</th>
<th>Japan</th>
<th>China</th>
<th>Taiwan</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>72</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>90%</td>
</tr>
<tr>
<td>Korea</td>
<td>2</td>
<td>62</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>77.5%</td>
</tr>
<tr>
<td>Japan</td>
<td>2</td>
<td>8</td>
<td>61</td>
<td>6</td>
<td>3</td>
<td>76.25%</td>
</tr>
<tr>
<td>China</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>64</td>
<td>6</td>
<td>80%</td>
</tr>
<tr>
<td>Taiwan</td>
<td>2</td>
<td>8</td>
<td>3</td>
<td>6</td>
<td>61</td>
<td>76.25%</td>
</tr>
</tbody>
</table>
5.2.2 Local Selection Strategy (LSS)

In this experiment, 10 one-against-one local feature sets respectively for English speaking countries and Non-English speaking countries are generated for classification. The number of features in each set is between 24 and 33, and is less than that in the global feature set. For the classification results illustrated in Table 5 and Table 6, the overall accuracy is around 80.75% and 84.5%, respectively and increases by 2.0% and 4.5% when compared with the results in Table 3 and Table 4. This result demonstrates that, without considering the other countries, more precise features can be selected for each pair of countries in order to get better classification results than the global feature set.

<table>
<thead>
<tr>
<th>First Language from</th>
<th>Canada</th>
<th>USA</th>
<th>Britain</th>
<th>New Zealand</th>
<th>Australia</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canada</td>
<td>67</td>
<td>2</td>
<td>5</td>
<td>6</td>
<td>0</td>
<td>83.75%</td>
</tr>
<tr>
<td>USA</td>
<td>4</td>
<td>61</td>
<td>8</td>
<td>6</td>
<td>1</td>
<td>76.25%</td>
</tr>
<tr>
<td>Britain</td>
<td>0</td>
<td>7</td>
<td>63</td>
<td>5</td>
<td>5</td>
<td>78.75%</td>
</tr>
<tr>
<td>New Zealand</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>64</td>
<td>2</td>
<td>80%</td>
</tr>
<tr>
<td>Australia</td>
<td>0</td>
<td>2</td>
<td>10</td>
<td>0</td>
<td>68</td>
<td>85%</td>
</tr>
</tbody>
</table>

| Precision           | 88.16% | 79.22% | 70.2% | 79.01% | 89.47% | 80.75% |

Table 5: Confusion matrix for English speaking countries by LSS.
5.3 Comparisons among All Methods
To compare our method with the other state-of-the-art methods, they were implemented on our dataset by using their features and classifiers. Especially for Yusnita et al. method, each speech in our dataset is cut into words and each word is recognized as the first language. Finally, the first language is determined using the majority voting of the predicted first languages of words. The comparisons and classification results are illustrated in Table 7 where our method performs much better than the other ones.

6. Conclusions
In this paper, we propose a speech recognition system to identify the first language of spoken English from English speaking countries and/or Non-English speaking countries. The original audio features used in the identification include pitch, timbre, rhythm, 146 dimensions in total.
Since some of them could be irrelevant, the SAHS (self-adaptive harmony search) algorithm is employed on the original features and select relevant features for facilitating first language classification. The experimental results show that the local selection strategy can achieve better accuracy than the global selection strategy and without using feature selection methods. The overall accuracy for English speaking countries and Non-English speaking countries can reach 80.75% and 84.5%, respectively. This demonstrates that more precise features can be selected for each pair of countries to get better classification results. In the future, we will integrate face visual features with the audio features to further improve first language recognition.

7. Acknowledgments
This work was supported by Ministry of Science and Technology of R.O.C. under grant MOST 104-2221-E-224-064.

8. References
Language and Image Processing, 25-30.


ICEAI-954
A New Scheme to Increase the Address Space of IPv4

Sanjay Kumar
Pt. Ravishankar Shukla University, Raipur (Chhattisgarh) 492010 India
sanraipur@rediffmail.com

Abstract
The current version of Internet Protocol is version 4 (referred as IPv4). Future version of Internet Protocol will be version 6 (referred as IPv6). At present, transition is going on from IPv4 to IPv6. But, how much time this transition will take is not possible to predict. Even some researchers doubt that whether the complete deployment of IPv6 will ever be able to see the light of day. Failure of IPv5 is already an alarm. Present work is an attempt to elongate the life of IPv4, so that IPv6 will get a breathing time for its deployment. This will also give space to rethink and research for even a better substitute than IPv6.

Keyword: Modified IPv4, IPng, CIDR, Checksum, IPv6, IPv4.

1. Introduction
Fundamental purpose of any communication system is the exchange of information between two parties. Source (sender), destination (receiver) and transmission medium are the three essential components of a communication system. There must be a high degree of cooperation between source and destination. Source (sender) and destination (receiver) need to follow certain protocol for communication. TCP/IP protocol architecture is a result of protocol research. TCP/IP protocol stack is used to interconnect multiple networks in internet. Nowadays a number of vendors are manufacturing and supplying variety of sophisticated instruments for modern communication system. Standards are needed for interoperability among different vendor equipments. This led the International Organization for Standardization (ISO) to develop Open System Interconnection (OSI). Open System Interconnection Reference Model does not specify protocol; rather it provides a common basis for development of standards aimed at system interconnection. OSI Reference model is based on layered architecture and consists of seven distinct layers. Upper four layers of OSI model take part in end to end communication and bottom three layers take part in hop to hop communication. If sender and receiver are connected through two or more interconnected networks, routing across these networks is needed. Network layer of OSI model is responsible for routing of packets through these networks. Corresponding layer in TCP/IP protocol suite is Internet layer. The Internet Protocol (IP) of Internet Layer provides routing across multiple networks. The current version of Internet Protocol is version 4 (referred as IPv4).
1.1 Motivation
A prime motivation is the realization of the fact that the address space provided by the current version of internet protocol IPv4 will not be enough in near future and future version of internet protocol IPv6 will take considerable time for deployment. Therefore, only way out to bridge up this gap is to extend the life time of IPv4. Classless Inter Domain Routing (CIDR) is an effort in this direction. Current work is also an attempt to extend the life time of IPv4.

1.2 Literature Survey
In order to overcome the deficiencies of IPv4 like inadequacy of address space, inability to transmit real-time audio and video signals and lack of encryption and authentication facilities IPv6 (Internet Protocol version 6), also known as IPng (Internetworking Protocol, next generation) was proposed and is now a standard [1]. In the year 1996, the American Registry for Internet Numbers (ARIN) reported that all of the IPv4 class A addresses had been assigned, 62 percent of the class B addresses had been assigned, and 37 percent of the class C addresses had been assigned [2]. As per the prevailing trends in address allocation at the time, the estimates were that addresses would be exhausted by 2018. Therefore, in the early 1990s, the Internet Engineering Task Force (IETF) initiated an effort to develop a successor to the IPv4 protocol [3]. In July 1992 a call for proposals for a next-generation IP (IPng) was issued by IETF, in response to which a number of proposals were received, and by 1994 the final design for IPng emerged. The effort resulted in to the publication of RFC 1752,“The Recommendations for the IP Next Generation Protocol” in January 1995[4]. As it was well realized that considerable time would be needed to deploy a new technology on such an extensive scale, and so the “Next Generation IP” (IPng) effort was begun [5] and at the same time effort to extend the life time of IPv4 was also started. The deployment of Classless Inter-Domain Routing was one such effort. An excellent online source of information about IPv6 is the IP Next Generation Homepage [6-7]. The deployment of Classless Inter-Domain Routing has been a milestone in extending the life time of IPv4 [8].

1.3 Problem specification
Currently process of transition from IPv4 to IPv6 is going on. This transition has already taken years, and is likely to take many more years [9-11]. Some people even think it will never happen [12]. Failure of IPv5 in real time deployment has already triggered an alarm [13].

1.4 Organization of paper
This paper is organized in seven sections. Section 1 gives an introduction to communication system, motivation behind the work and an elaborate literature survey. Section 2 gives an overview of IPv6 and explains why it is needed. Section 3 describes header formats of IPv4 and IPv6 and their effects on performance. Section 4 discusses the proposed scheme, named as Modified IPv4 and its possible impact on network classes and performance. Brief description
of simulation is given in section 5. Section 6 gives results and discussion and finally the paper ends with conclusion in section 7.

2. Overview of IPV6

The future version of Internet Protocol is version 6. This is referred to as IPv6 or IPng. Researchers working on a new version of IP wanted to give a temporary name, which they borrowed from a popular television show and named it as IP-the Next Generation. Therefore, many early reports referred to IPv6 as IPng.

2.1 Goals of IPv6

Major goals of IPv6 are to
- Support billions of hosts, even with inefficient address space allocation.
- Reduce the size of the routing tables.
- Simplify the protocol, to allow routers to process packets faster.
- Provide better security (authentication and privacy) than current IP.
- Pay more attention to type of service, particularity for real-time data.
- Aid multicasting by allowing scopes to be specified.
- Make it possible for a host to roam without changing its address.
- Allow the protocol to evolve in the future.
- Permit the old and new protocols to coexist for years.

IPv6 meets these goals fairly well.

2.2 Challenges with IPv6

Internet Routers need to perform packet forwarding at high speed. IP address look up is one of the most challenging tasks due to rapid growth of internet and scalability towards IPv6. The current solution for IP address look up is confronted with scalability issue [14].

3. Comparison of IPV4 and IPV6 Packet Formats

In packet switching message travels in form of packets. Network layer is responsible for routing of packets from source to destination. Each packet carries source address and destination address. These addresses along with some more information are encapsulated within a unit called packet header. A packet contains packet header followed by data. Figure 1 and Figure 2 show the structure of packet header belonging to IPv4 and IPv6 packets. We notice that IHL, Type of Service, Identification, Flags, Fragment Offset, Header Checksum and Options fields appearing in the IPv4 datagram are no longer present in IPv6 datagram. Total Length, Time to Live, Protocol, Source Address and Destination Address fields are changed in IPv6. In IPv6 work of fragmentation and reassembly is performed only by the end systems i.e. source and destination and not by the routers. If at all the IPv6 datagram received by router is too large to forward, then the router drops the datagram and sends an ICMP message to sender.
saying “packet too big”. Then the sender fragments and resends the data in smaller data grams. Fragmentation and reassembly was time consuming work and relieving routers from this job speeds up routing. Checksum is calculated for error detection. Calculating checksum is most time consuming part of header as it needs to touch every data byte once [15]. Since checksum is calculated by data link (for example, Ethernet) and transport layer (for example, TCP and UDP) protocols, internet layer is relieved of this functionality resulting in to faster processing at router. Time to Live (TTL) field of IPv4 is similar to Hop Limit in IPv6. The options field of IPv4 is one of the possible “next headers” pointed to from within the IPv6 header. The removal of the options fields results in a fixed length, 40-byte IP header.

3.1 Effect of Packet Format on Performance
As header length in IPv6 is 40 bytes as compared to 20 byte in IPv4 header, the overhead per packet is doubled in IPv6. According to one prediction future internet will carry small packets [15]. An example of this is ATM networks, which use small fixed length packets called cells. Cell routing is done in hardware. Therefore, hardware routers may be used to handle short and fixed length cells. Variable length IP packets have to be routed through software, which is a slower process. Further, small cells do not block any line for long, which makes guaranteeing quality of service easier [13].

Still one advantage with IPv6 is that although the IPv6 header is longer it contains fewer fields (8 versus 12). Thus, routers have less processing to do per header, which should speed up routing [17].

3.2 Review of Previous Work on Performance Comparison
Performance comparison between two IPv6 implementations running on Windows 2000 and Solaris 8 is reported by researchers [18]. In an incremental research performance comparison of IPv4 and IPv6 on Windows 2000, Solaris 8 and Linux platforms is also reported [19]. Results of these comparisons is that although IPv6 might solve several of IPv4’s shortcomings, but the longer headers and address space add overhead that affects a range of performance metrics. In an interesting research at Karpagam University, Tamilnadu researchers [20] have compared the performance of IPv4 and IPv6 using on line examination server of their university and five different networks each consisting 60 computers. Their findings reveal that round trip time and packet loss probability are less in IPv4 as compared to IPv6.

All these analyses show that IPv4 with little modification may be a better alternative.

4. Purposed Scheme To Extended The Address Space in IPV4
As it is clear from the figure of IPv4 that there are three flag bits present in IPv4 header, which are called Unused Bit, DF (Don’t Fragment) bit and MF (More Fragment) bit . Out of these
three flag bits the unused bit was reserved for future use, but it was never used. In the proposed scheme this unused bit is named as ‘S’ bit and is used for prefixing the source IP address. Researchers have argued that IP fragmentation is a bad idea, because it adds to the router’s work and introduces complexity [15-16]. IPv6 also does not allow fragmentation at intermediate routers. Therefore, in present work DF flag bit of IPv4 is also safely dropped and is renamed as ‘D’ bit. This ‘D’ bit is used to prefix the destination IP address. Prefixing of ‘S’ and ‘D’ bit in source and destination IP addresses provide 33 bits for IP address instead of 32 bits. Therefore, IP address range gets doubled i.e. becomes 233 from 232.

4.1 Effect on Classes of Networks
Without disturbing the original classification of networks in A,B,C,D and E classes all the networks may be categorized under two super classes namely ‘X’ and ‘Y’. Classes A, B, C, D and E may belong to super class ‘X’ or super class ‘Y’. If ‘S’ or ‘D’ bit is set to zero, the corresponding IP address belongs to Super Class X. If ‘S’ or ‘D’ bit is set to one, the corresponding IP address belongs to Super Class Y. Since, IPv4 is still not full, all the existing networks and packets may be put under the category of super class ‘X’. That is, ‘S’ and ‘D’ bits may be set to zero.

4.2 Effect on performance – Introduction of ‘S’ bit in place of unused bit and ‘D’ bit as a replacement of DF bit are such a little modification that neither the size of packet nor the broad layout of packet changes. However, router may have to spend slightly more time in processing these bits for each packet. This may result in to slight increase in delay which may be regarded as negligibly small for all practical purposes.

5. Simulation
Packets of IPv4 and IPv6 can be generated and captured by making use of ‘PackETH’ and ‘Wireshark’ network analyzers. But, packets of modified IPv4 are not possible to generate with PackETH. Therefore, C language was used for simulation as it provided better control to play with the internal structure of IPv4 packet. Classical method and algorithm for simulation of Banyan Network proposed by Hussain and Jenq [21] made the basis for simulation undertaken in the current work. Packets of IPv4, modified IPv4 and IPv6 were generated randomly using ‘struct’ command of ‘C’ language and were injected on a 3 stage, 8 x 8 Banyan Network assuming that the routers of subnet are arranged in the topology of Banyan Network. Simulation Program was run for 1000 cycles. For further details of simulation paper of Hussain and Jenq [21] may be referred. Results of simulation are plotted in figure 4.

6. Result And Discussion
Because of the difference in header lengths IPv6 packets are expected to occupy almost double space in memory as compared to IPv4 packets. However, IPv4 and modified IPv4 packets are expected to occupy the same memory. Processing time taken by router is considerably more in IPv6 than IPv4 (and modified IPv4 packets). Processing time of modified IPv4 packets is only
marginally more than IPv4 packets due to the additional bit in its header. Accordingly, the network performance is found to be the best in IPv4 because of its simple and small structure. Network performance is slightly inferior in modified IPv4 due to one extra bit in header. However, this degradation is negligibly small. But, this degradation is quite significant in IPv6 because each packet of IPv6 occupies almost double space in memory and requires more processing at router.

7. Conclusion
A new scheme, under the name of modified IPv4 is proposed in this paper to double the address space of IPv4. Since, there is very little change in IPv4, modified IPv4 can be deployed easily. This scheme gives good performance and will not disturb original network classification scheme. Though this scheme cannot be a replacement of IPv6, it can be useful in extending the life time of IPv4 and hence will make the transition from IPv4 to IPv6 smooth.

8. References
ARIN, “IP allocation report” ftp://rs.arin.net/netinfo/ip_network_allocations
<table>
<thead>
<tr>
<th>Version</th>
<th>IHL</th>
<th>Type of service</th>
<th>Total length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identification</th>
<th>D</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fragment offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time to live</th>
<th>Protocol</th>
<th>Header checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Destination Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Options (0 or more words)**

---

**Fig.1: Packet format of IPv4**

---

<table>
<thead>
<tr>
<th>Version</th>
<th>Traffic class</th>
<th>Flow label</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Payload length</th>
<th>Next header</th>
<th>Hop limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>(16 Bytes)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Destination Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>(16 Bytes)</td>
</tr>
</tbody>
</table>

---

**Fig.2: Packet format of IPv6**

---

<table>
<thead>
<tr>
<th>Version</th>
<th>IHL</th>
<th>Type of service</th>
<th>Total length</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Identification</th>
<th>S</th>
<th>D</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fragment offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time to live</th>
<th>Protocol</th>
<th>Header checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Destination Address</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>

**Options (0 or more words)**

---

**Fig.3: Proposed Packet format of Modified IPv4**

447
Fig. 4(a): Graph between Input Traffic Load and Normalised Throughput

Input Load: Number of packets per input link per cycle

Normalized Throughput: Number of packets per output link per cycle

Normalized Delay: Number of cycles per stage

Fig. 4(b): Graph between Input Traffic Load and Normalised Delay
ICEAI-1208
Real-Time Transcoding and Cloud Resource Allocation of Adaptive Multimedia Stream System for Multiple Channels and Multiple Users

Hui-Kai Su\textsuperscript{a}, Cheng-Shong Wu\textsuperscript{b}, Chang-Ming Lee\textsuperscript{b}, Yun-Ying Zeng\textsuperscript{b}, Yan-Sun Chu\textsuperscript{b}, Ching-Lung Chang\textsuperscript{c}

\textsuperscript{a} Department of Electrical Engineering, National Formosa University, Taiwan (R.O.C.)
E-mail address: hksu@nfu.edu.tw

\textsuperscript{b} Department of Communications Engineering, National Chung Cheng University, Taiwan (R.O.C.)

\textsuperscript{c} Department of Computer Science and Information Engineering, National Yunlin University of Science and Technology, Taiwan (R.O.C.)

Abstract
With the development in Internet technology, mobile and handheld devices with multimedia compression technologies, the users can surf the Internet to watch video entertainment contents at anytime and anywhere. That is making multimedia streaming service has become an integral part of daily life. Therefore, various internet video services are increasingly completed. In order to provide a suitable platform for heterogeneous video streaming service, it has to transcode on demand. However, real-time video transcoding requires a lot of cloud computing resources, it is difficult to achieve in the general terminal device. With the cloud computing technologies, the computing server in the transcoding cloud will serve and satisfy the requirements of different terminal equipment. This paper proposes a real-time transcoding of adaptive multimedia stream system. To meet the requirement of real-time transcoding, the cloud resource allocation mechanism was also design in this paper. According to the resolution, quality and other conditions desired by the users, the cloud management configures the optimum number of virtual machines to deal with the cloud transcoding task. Finally, the system prototype was design and implemented. In our testbed, two clients were playing live streams with difference programs simultaneously. While the state of available bandwidth is changed, both clients can adapt the stream to fit the network condition. Both video programs were still playing smoothly and continuously. The adaptation delay is about 15 seconds.

Keywords: video transcode, cloud computing, resource allocation, adaptive multimedia stream

1. Background/ Objectives and Goals
With the development in Internet technologies, mobile and handheld devices with multimedia compression technologies, the users can surf the Internet to watch video entertainment contents
at anytime and anywhere. That is making multimedia streaming service has become an integral part of daily life. Therefore, various internet video services are increasingly completed. In order to provide a suitable platform for heterogeneous video streaming service, it has to transcode on demand. However, real-time video transcoding requires a lot of cloud computing resources, it is difficult to achieve in the general terminal device. With the cloud computing technologies, the computing server in the transcoding cloud will serve and satisfy the requirements of different terminal equipment.

Moreover, to transmit multimedia as much as possible, User Datagram Protocol (UDP) is frequently adopted in network. However, UDP is unreliable because of lacks of congestion control mechanism. Unfortunately, the fast growing real-time application may lead Internet into congestion collapse, especially with the unresponsive UDP protocol over the error-prone wireless network. In opposition, the transmission rate variation is considered by Transmission Control Protocol (TCP). According to the network transmission quality, the transmission rate and request of retransmission of lost packets can be adjusted by the Additive-Increase/Multiplicative-Decrease (AIMD) Y. R. Yang & S. S. Lam (2000) which realizes the congestion control. Consequently, the transmission of multimedia streaming can be achieved completely. The perception of quality change remains, because the conditions (buffering, playback time, etc.) in the client part are rarely regarded in the congestion control.

Recently, HTTP Live Streaming (HLS) has been released by APPLE for HTTP-based media streaming communications protocol. However, there are several limitations, like company-independent streaming servers as well as playback clients. Based on TCP, pull-based media streaming protocol can check URL information in the segment list received by the client and transmit segments with competent quality by HTTP over TCP. This scheme can support the compatibility among various platforms and completeness of media transmission in the open network. In this trend, Moving Picture Experts Group (MPEG) developed MPEG-DASH (Dynamic Adaptive Streaming over HTTP) in 2012 I. Sodagar (2011) to standardize the compatibility among various devices or servers. In this protocol, the packet format, segmentation of streaming file, and segment delivering are defined to provide the flexibility to design an adaptive algorithm for the dynamic network environment. To smooth HTTP throughput, several adaption schemes based on bandwidth conditions C. Liu, I. Bouazizi & M. Gabbouj (2011) and buffer conditions L. De Cicco & S. Mascolo & P. Vittorio (2011) and C. Zhou & C.-W. Lin & X. Zhang & Z. Guo (2014) instead of instantaneous TCP transmission rate are proposed to improve the performance of the HTTP
streaming services. The challenge remains on the combination of these issues to smoothly adjust the video bitrate or the quality of experience (QOE) over the video streaming services.

The goal of this paper is to design a cloud transcoding system to achieve real-time transcoding for live streams. While the state of available bandwidth is changed, the video should be adapted to a suitable video quality and meet the real-time requirements of live streams.

2. Methods

2.1 System Architecture

This paper proposes a real-time transcoding of adaptive multimedia stream system, which is shown in Fig. 1. Based on the IaaS (Infrastructure as a Service) cloud transcoding technologies, the live programs of multi-channel DVB-T will be transcoded for various devices, such as HDTV (High Definition Television), personal computer, smart phone, etc. Moreover, the transcoded streams are constructed with MPEG-Dash format. When the network state changes, the terminal devices will trigger to upgrade or downgrade the video quality by monitoring the state of receive buffer. Sequentially, our system will transcode the suitable video quality for the terminals on demand. Thus, the terminal devices can receive the adaptive stream with different qualities according the available bandwidth in transportation networks.

2.2 Cloud Transcoder

To realize a real-time video transcoding service, an IaaS system is constructed as a transcoding cloud. Fig. 3 presents the components of the proposed cloud system. Font-end is in charge of managements in the transcoding cloud, including ONED, drivers, guest OS images, monitoring of system resource in physic and virtual machine, etc. Cluster node can offer the computation resource by dynamically processing and removing the VM instance which contains an individual guest OS and provides the transcoding service. Transcoding proxy (TP) can provide the NFS storage service and process the dynamic allocation (proposed in Section III-C. Therefore, each VM can access the corresponding video chunks before transcoding.
MPEG-DASH formatting can packetize the transcoded chunks and generate MPD for the client.

2.3 Earliest finishing time first VM allocation

To meet the requirement of real-time transcoding, the cloud resource allocation mechanism was designed in this paper. Some transcoding task just need one VM (virtual machine), but some complex transcoding task requires more computing resource with multiple VMs. According to the resolution, quality and other conditions desired by the users, the cloud management configures the optimum number of virtual machines to deal with the cloud transcoding task. Thus, the earliest finishing time first VM allocation was proposed in this paper.

When TP accesses a video chunk in the cloud, this allocation mechanism can estimate the transcoding time in each VM and select the fast one to realize the transcoding of this chunk. The dynamic update of transcoding rate for each VM is necessary to successfully estimate the transcoding time and adjust the number of virtual transcoder to satisfy the required transcoding delay. The transcoding rate is normalized by dividing the playout time of a chunk (several segments) by the transcoding time. Several parameters are defined as follows.

\[ t_i^j: \text{Processing time of } i\text{th chunk in } j\text{th transcoder.} \]
\[ l_i^j: \text{Arrival time of } i\text{th chunk.} \]
\[ T_i^j: \text{Playout time of } i\text{th chunk.} \]
\[ f_i^j: \text{Finish time of } i\text{th chunk on } j\text{th transcoder.} \]
\[ D_{max}: \text{Maximal transcoding delay.} \]
\[ R_j: \text{Transcoding rate of } j\text{th transcoder.} \]

The transcoding rate depends on the desired quality, video characteristics, capability of VM, and payload of physical machine. The policy is described below.

Step 1: Find the initial number of available VM by

\[ K = \arg \left( \min \left( \sum_{j=1}^{n} R_j > 1 \right) \right) \]  \hspace{1cm} (1)

Step 2: Estimate the ith chunk transcoded by the jth transcoder as
3. Results

The test environment in this paper is shown in Fig.5. MPEG-DASH video streaming data is transmitted between HTTP server and client with unicast (HTTP over TCP). The Traffic Control (TC) is realized by the Linux kernel in the HTTP server. The resolution of original video streaming is 1920x1080 with bitrate 13 Mbps and framerate 30 Hz. Three qualities
considered in this transcoding cloud are $Q_{\text{low}}$ for 1Mbps, $Q_{\text{mid}}$ for 3 Mbps, and $Q_{\text{high}}$ for 5 Mbps. The performance of proposed algorithm is evaluated with the available bandwidth variation. The initial delay is about 16 seconds. The test environment is illustrated in Fig. 2.

In this experiment of cloud resource allocation, round Robin (RR) algorithm and Most Powerful Available Transcoder First (MPATF) algorithm are considered for comparison that are shown in Table I. With RR, the sequential chunks are allocated in the corresponding VMs in order by the transcoding proxy. The number of transcoders would be increased while the assigned VM is busy (not available). Instead of sequential assignment, MPATF can select the most powerful VM in the pool (containing all available VMs) to finish the transcoding as fast as possible. In the result, we can observe that our proposed scheme (EFTM) can provide real-time transcoding with the minimal number of transcoders.

<table>
<thead>
<tr>
<th>Utilization</th>
<th>TC1</th>
<th>TC2</th>
<th>TC3</th>
<th>TC4</th>
<th>TC5</th>
<th>Number of transcoder</th>
</tr>
</thead>
<tbody>
<tr>
<td>RR</td>
<td>52.12</td>
<td>51.68</td>
<td>52.31</td>
<td>50.36</td>
<td>44.77</td>
<td>4.46</td>
</tr>
<tr>
<td>MPATF</td>
<td>63.08</td>
<td>64.97</td>
<td>18.96</td>
<td>2.96</td>
<td></td>
<td>2.96</td>
</tr>
<tr>
<td>EFTM</td>
<td>81.91</td>
<td>81.04</td>
<td>45.64</td>
<td></td>
<td></td>
<td>2.1</td>
</tr>
</tbody>
</table>

For the adaptive streaming, in our testbed, two clients were playing live streams with difference programs simultaneously. Moreover, the available bandwidth of each client is controlled by the WAN emulator that was achieved by “tc” command in Linux platform. Figure 3 and Figure 4 are shown the test results. While the state of available bandwidth is changed, both clients can adapt the stream to fit the network condition. Both video programs were still playing smoothly and continuously. The adaptation delay is about 15 seconds.

4. Rerefence


Fig. 3: The test result of client 1.

Fig. 4: The test result of client 2.
1. Background/ Objectives and Goals
Disease of the soybean crop is one of the obstacles to increased soybean production in Indonesia. Some of these diseases usually find in leaves and cause the crop become unhealthy. This study aims to identify disease on soybean by using leaf image. The diseases were identified in this study are downy meldew and karat.

2. Methods
This study applies the method of Learning Vector Quantization (LVQ) to identify disease on soybean leaf image. The process of identification begins with preprocessing using Otsu method. This method is used to get part of the disease on the leaves with a certain threshold value. Then extracting the features of the disease on all the imagery of soybean leaves. The feature consist of the minimum value, the maximum value and the average value of red, green and blue. Furthermore, the features are used as input in the process of training on the training data by using LVQ to get the final weight. And the final weight was used to test the image of the test data using LVQ.

3. Expected Results/ Conclusion/ Contribution
Tests conducted in this study is testing a threshold value variable (C) on Otsu method, and testing of LVQ parameters that consist of the initial weight, the value of learning rate, the value of learning rate deduction and the amount of training data. Based on the five test on variables obtained the optimum threshold value is 80, the initial weight is 1-1.jpg 2-1.jpg, the value of learning rate of 0.1, the value of a deduction learning rate of 0.1 and the amount of training data
is 60. The result of test on testing data by using the value of all recommendations parameters obtained the highest accuracy of 93%.

**Keywords**: leaf soybean disease, digital image, Learning Vector Quantization, Otsu
Biological Sciences (2)

Wednesday, May 11, 2016  16:30-18:00  Room 1007

Session Chair: Prof. Anrug Poeaim

ICCBES-1213
Plant Growth-Promoting Traits of Yeasts Isolated from Drosera Spatulata Lab.
Bai-You Cheng | TransWorld University
Wei-Ta Fang | National Taiwan Normal University
Shih-Feng Fu | National Changhua University of Education
Jui-Yu Chou | National Changhua University of Education
Pei-Feng Sun | National Changhua University of Education
Hsueh-Yu Lu | National Changhua University of Education
Jyuan-Yu Wei | National Changhua University of Education
Hong-Su Xiao | National Changhua University of Education

ICCBES-1295
Immunostimulant Potential of Aqueous Extract Bangunbangun (Plectranthus Amboinicus L. Spreng) Leaf in Rat Induced BCG as Antigen
Melva Silitonga | State University of Medan
Pasar Maulim Silitonga | State University of Medan

ICCBES-1299
Isolation, Characterization and Screening for Anticancer and Antimicrobial Properties of the Crude Extract from Genus Neosartorya
Supattra Poeaim | King Mongkut’s Institute of Technology Ladkrabang
Kongluekai Tongkantom | King Mongkut’s Institute of Technology Ladkrabang
Prapaiporn Jabamrung | King Mongkut’s Institute of Technology Ladkrabang
On Bo-Kaew | King Mongkut’s Institute of Technology Ladkrabang
Mayamor Soytong | King Mongkut’s Institute of Technology Ladkrabang
ICCBES-1302
Optimization for Callus Induction and Plant Regeneration from Mature Seeds of Thai Rice Variety: Nam Roo (Oryza sativa L.)
Anurug Poeaim | King Mongkut’s Institute of Technology Ladkrabang
Supattra Poeaim | King Mongkut’s Institute of Technology Ladkrabang
Ranyikar Poraha | King Mongkut’s Institute of Technology Ladkrabang
Saengthong Pongjaroenkit | Maejo University
Pradit Pongthongkam | Thepstri Rajabhat University

ICCBES-1265
Utilization of Meat and Waste from Sandfish (Holothuria Scabra) Environmentally Friendly for Anti-Aging Source Material for Elderly Woman
Etty Riani | Bogor Agricultural University
Chairunissa Chairunissa | Bogor Agricultural University
Hera Maheswari | Bogor Agricultural University
Muhammad Dzikrifishofa | Regional General Hospital of Leuwiliang, Regency of Bogor
Abstract
Microorganisms can promote plant growth by both direct and indirect mechanisms. These beneficial organisms can use as biofertilizer, biopesticides as well as agents in the phytoremediation process. However, the potential of yeasts used as plant growth promoting agents has been less investigated by researchers. In this study, yeast isolates from the phyllosphere and rhizosphere of the medicinally important plant *Drosera spatulata* Lab. were assessed for their plant growth-promoting (PGP) traits. All isolates were tested for indole-3-acetic acid-, ammonia-, and polyamine-producing abilities, calcium phosphate and zinc oxide solubilizing ability, and catalase activity. Furthermore, the activities of siderophore, 1-aminocyclopropane-1-carboxylate deaminase, and fungal cell wall-degrading enzymes were assessed. The antagonistic action of yeasts against pathogenic *Glomerella cingulata* was evaluated. The cocultivation of *Nicotiana benthamiana* with yeast isolates enhanced plant growth, indicating a potential yeast-plant interaction. Our study results highlight the potential use of yeasts as plant biofertilizers under controlled and field conditions.

Keywords: biofertilizer, *Drosera spatulata*, phyllosphere, rhizosphere, yeast
ICCBES-1295

Immunostimulant Potential of Aqueous Extract Bangunbangun (Plectranthus Amboinicus L. Spreng) Leaf in Rat Induced BCG as Antigen

Melva Silitonga\textsuperscript{a}, Pasar Maulim Silitonga\textsuperscript{b}\textsuperscript{*}

\textsuperscript{a} Biology Department, State Medan University, Indonesia
\textsuperscript{b} Chemistry Department State Medan University, Indonesia

Pasar.silitonga@gmail.com

Abstract

The objective of this research is to evaluate the immunostimulant potential of aqueous extract of P. amboinicus (Plectranthus amboinicus (Lour) Spreng) leaf (AEP) in rats (Rattus norvegicus L.). 24 male rats aged 3 months and weighing between 140-200 grams divided equally into six groups, P1, P2, P3, P4, P5 and P6. P1 as control was given aquadest. The P2, P3, P4, P5 and P6 treatment groups were given 19 g / kg AEP + BCG, 31.5 g / kg AEP + BCG, 19 g / kg AEP, 31.5 g / kg AEP and BCG consecutively. The BCG were used as antigen. The AEP was administered orally for 30 days and 100 µl BCG were intramuscularly administered on day 14th and day 21. Parameters that are included in this research are IgM and SGPT, SGOT concentration. On day 31st, the rats were decapitated and their blood were collected. IgM were measured using ELISA technique, DiaLab Kit was used to measure the concentration of SGPT and SGOT with spectrofotometric technique. Data were analyzed using one way Anova with LSD. Result of this research showed that the AEP improved IgM significantly (p < 0.05) in the treatment of P3, P4 and P5 as compared to the control treatment. BCG does not give effect to IgM levels. AEP decreased SGOT and SGPT significantly (p<0.05) in the treatment of P2, P3, P4 and P5. It showed the hepatoprotective properties AEP thus maintaining liver function in normal circumstances. As a conclusion that AEP potential as immunostimulan because it increases the body's defense immunoglobulin in response to an antigen. AEP preserve liver function in the normal physiological state that its function as one of the organs of the body's defenses to be maintained. The results of this study contributed to the efforts to improve the body's immune system. Further study is sugessted to isolate and characterize the active substances contain in P. amboinicus leaves and tested as immunostimulant and anti-tumor

Keywords: Immunostimulant Plectranthus amboinicus (Lour) Spreng, IgG, SGOT, SGPT

1. Background/ Objectives and Goals

Immune system is the maintaining authority of the living system. Both innate and acquired immunity are extremely important for the maintenance of good health. Plectranthus amboinicus (Lour) Spreng is a medicinal plant that has many benefits, such as an antioxidant,
hepatoprotective and immunostimulant. Immunostimulant are substances that can increase the body's resistance to infections. Various immunomodulators have been reported to enhance non-specific immunity. Immunomodulator is a way to restore and repair the compromised immune system and suppress excessive immune function (Gordon and Austyn, 2012). Immunomodulatory agents that origin from plants and animals increase the immune responsiveness of the body against pathogens by activating primarily the non-specific and specific immune system, example stimulation funtion and efficiency of immunoglobulin dan the liver as immune organ. However the drugs should be subjected to systematic studies to substantiate the therapeutic claims with regard to their clinical utility.

The uses of medicinal plants in traditional medicine are widespread and still serve as leads for the development of novel pharmacological agents. Many such medicinal plants have hepatoprotective, neuroprotective, anti-inflammatory and also antioxidant or radical-scavenging properties (Phillai, 2011). *Plectranthus amboinicus* Lour.(Spreng) (*Coleus amboinicus*, *Coleus aromaticus*) commonly known as Indian borage, country borage is a dicotyledonous plant belonging to Lamiaceae family. The content of the *Plectranthus amboinicus* leaves that serve as immunostimulant namely vitamin C (Pracash, 2012), flavonoid (Hullatti and Bhattacharjee. 2011) in particular classes of flavonols .The benefits of *Plectranthus amboinicus* leaves as immunostimulatory will be assessed by measuring immunoglobulin (Silitonga and Situmorang, 2013) which acts as an antibody to kill the antigen enters the body. In *Plectranthus amboinicus* leaves, there are also vitamin B1, vitamin B12, beta carotene, niacin, carvacrol, calcium, fatty acids, oxalic acid, and fiber (Pracash, 2012). These compounds have potential for a variety of biological activities, including as immunostimulan. However, Sunita et al (2010) had reported there research that the *Plectranthus amboinicus* leaves as immunostimulatory to the fish. *Plectranthus amboinicus* has many benefits, as an antipyretic, analgesic, wound medicine, cough, and thrush, antioxidant, antitumor, anticancer, and hypotensive (Duke, 2000; Shivaji et al., 2014). Usually drugs that having multifunction has receptors on the target organ limforetikular systems that perform immune functions. Bio-active substances which suspected in *Plectranthus amboinicus* leaves as immunostimulan are flavonoids, steroids, and polyphenols. Flavonoids are antioxidants to prevent the oxidation of low density lipoprotein (LDL) and lower risk of atherosclerosis. Antioxidants contained in food can stimulate cellular immunity and help preventing oxidative damage to cellular components. However there is no report on the immunostimulatory activity of *Plectranthus amboinicus* Lour. Immunoglobulin M on the other hand is found mainly in the lymph fluid and in blood. This is the first antibody that is produced by the human fetus. It is also the first antibody that is produced in case of an exposure to a particular disease. The liver is an organ with predominant innate immunity, playing an important role not only in host defenses against invading microorganisms and tumor transformation but also in liver injury and repair (Gao et al., 2008). The purpose of the present study was examine the effect of the aqueeous
extract of *Plectranthus amboinicus* L (AEP) leaf on immunoglobulin M (IgM) and liver function in rats as an immune response.

2. **Methods**

**Animals**
Male rats (3 months and between 140-200 g in body weight) were used in the study. The animals were maintained at room temperature on 12 h light – 12 h dark cycle. They were fed with standar pellet diet, and tap water *ad libitum*. Rats were placed in plastic cages measuring 40 x 25 x 20 cm, at the top of the cage is equipped with a wire cover. Each cage is filled with chaff as the base and then placed three rats per cage. Acclimatization is done for 7 days.

**Plant Material**
A total of 500 grams of fresh leaves sliced into small pieces and fresh juice obtained by adding 30 ml of water, with the aid of a mixer. Juice fresh filtered and deposited into dry ingredients using a vacuum distillation. Dry residue obtained as much as 16 g (Jose et al., 2005). AEP dose for rats is determined based on a daily consumption of Batakseece (Santosa et al., 2002), namely 150 g / 50 kg bw, then converted into rats. Conversion is done by looking at the dose conversion table according to Laurence and Bacharach, (1964). which is determined on the human body weight and mice 70.Kg 200.g

**Experiment Design**
Complete randomized design was used in this experimental research and 24 male rats aged 3 months and weighed between 140-200 grams were used. Rats were divided into six treatments groups, each group consists of four rats. The first treatment group as control (P1) was given aquadest. The second (P2), third (P3), fourth (P4), fifth (P5) and the sixth (P6) treatment groups were given 19 g / kg AEP + BCG, 31.5 g / kg AEP + BCG, 19g / kg AEP, 31.5 g / kg AEP and BCG consecutively. The BCG were used as antigen. The AEP was administered orally for 30 days and 100 µl BCG were intramuscularly administered on day 14 th and day 21. Parameters that are included in this research are IgM and concentration of SGPT and SGOT of serum. On day 31st, the rats we decapitated and their blood were collected. IgM were measured using ELISA technique, DiaLab Kit was used to measure the concentration of SGPT and SGOT with spectrophotometric technique. Data were analyzed using one way Anova with LSD.

3. **Expected Results/ Conclusion/ Contribution**

3.1. **Results**

3.1.1. **Immunoglobulin M (IgM)**
Result of this research (Table 1) showed that the AEP improved IgM significantly (p < 0,05) in the treatment of P3, P4 and P5 as compared to the control treatment. BCG does not give effect
Immunoglobulin (antibody) is a protein synthesized by the animal in response to foreign substances and was a parameter that indicates the state of the body's immune. In this study measured immunoglobulin are immunoglobulin M (IgM). In Table 1 it can be seen that the IgM increased significantly in treatment P3, P4 and P5 as compared to controls treatment. The highest increase was in treatment P4 and P5 which such treatment is only given AEP. Some of the chemical content of leaves of *P. amboinicus* that can increase the body's immune system is flavonoids, alkaloids and saponins. Saponins can enhance immune response and acts as adjuvant (Rajput et al., 2007). Phytochemicals such as alkaloids, flavonoids, pigments, terpenoids, steroids, and essential oils are a large group of components commonly found in vegetables, fruits and cereals (Chakraborty and Hancz, 2011). The phytochemical substances can increase the innate immune system and antibacterial.

*P. amboinicus* (AEP) contribute to increased levels of serum immunoglobulin in rats in this study. Increased serum immunoglobulin in rat given aqueous extract of the leaves of *P. amboinicus* (AEP) because of some things that can be explained as follows. First. the saponins which act as immunostimulan. *P. amboinicus* leaves contain saponin as reported by Prakash (2011). Saponin is a natural substance found in the active site glycosides, mainly produced by plants and also by small marine animals and some bacteria. Some studies indicate physiological properties, immunological and pharmacological saponin, which makes it as important in the treatment of substance (Francis et al., 2002). Furthermore that saponin is as immunostimulan but the mechanism is not clearly revealed. Some opinions explaining saponins can induce cytokines such as the interleukins and interferons that can show immunostimulatory effects. Saponins enhance the immune system by increasing antibody in the body. Saponin triterpenoids from root
extracts of Achyranthes aspera that was given for 4 weeks increases antibodies and gamma globulin serum in fish (Rao et al., 2004). Secondly, another possibility AEP contribution in improving the immunoglobulin are the alkaloids and flavonoids. According to Sharma et al (2007) flour Withania somnifera plant roots that are high in alkaloid and given 1.0 and 2.0 and 3.0 g / kg bw on the fish was able to increase the activity of phagocytic cells, levels of total immunoglobulin and lysozyme activity. But how the mechanism of action of flavonoids in increasing the activity of the immune system is not explained. According Khoul and Khosa (2013) phytochemical alkaloid is an immunomodulator. As an immunomodulator alkaloid contained in the plant Melissa officinalis showed immunomodulator function by increasing significantly antibody titers in the blood circulation and the number of total leukocytes. The third, P. amboinicus leaf also contain vitamin C, BI, B12, beta-carotene, niacin, karvakrol, calcium, fatty acids, oxalic acid, and fiber (Duke 2000). According to Heyne (1987) of 120 kg of fresh leaves contained approximately 25 ml of volatile oil containing phenol (isopropyl-o-cresol) and on that basis he states that P. amboinicus is antiseptikum high value. Vitamin C, vitamin B12, and beta-carotene is also a substance that can stimulate the formation of antibodies in the body.

3.1.2. SGOT and SGPT

In this study, the levels of SGOT was highest in control mice, while the three other treatments is lower than in the controls (Table 1). SGOT levels in rats treated with P2, P3, P4 and P5 decreased significantly as compared to the controls treatment. The decrease in treatment AEP SGOT showed hepatoprotective properties P. amboinicus. This is in line with research Pillai (2013) in which the methanol extract of leaves of P. amboinicus 200 mg and 400 mg / kg bw in mice lowers SGOT. Thus the hepatoprotective effect of the leaves of P. amboinicus will support in improving the body's immune system through the maintenance of liver function. Shenoy et al (2012) reported the ethanol extract of the leaves of P. amboinicus serves as a hepatoprotective against paracetamol induced in rat. Hepatoprotective nature is shown by the decrease in SGOT in serum after administration leaf extract of P. amboinicus.

SGPT (Piruvic Serum Glutamic transaminase), is enzymes are numerous hearts and will be out of the cell if there is an infection in the heart. Award AEP and AEP + BCG in this study significantly to lower levels of ALT. SGOT lowest is in the rat treated BCG + AEP and AEP. SGOT and SGPT in this study were within the normal range. Decreased levels of ALT in this study showed hepatoprotective properties of leaves of P. amboinicus. This is consistent with the Patel (2011) research which showed that the ethanol extract of the leaves of P. amboinicus 500 mg / kg bw in rats induced by CCl4 can decreased serum alanine aminotransferase levels significantly and renewed hepatosit damaged by CCl4. The results of this study prove the hepatoprotective effect of the leaves of P. amboinicus so well preserved liver function and the immune system is made by the liver goes well.
3.2. Conclusion

In conclusion, this study demonstrates that the aqueous extract of Plectranthus amboinicus Lour Spreng contains bioactive agents that influence immunoglobulin parameter and levels of liver enzymes in rats. AEP potential as immunostimulant because it increases the body's defense immunoglobulin in response to an antigen. It showed the hepatoprotective properties AEP thus maintaining liver function in normal circumstances. AEP preserve liver function in the normal physiological state that its function as one of the organs of the body's defenses to be maintained. The results of this study contributed to the efforts to improve the body's immune system. Further study is suggested to isolate and characterize the active substances contain in P. amboinicus leaves and tested as immunostimulant and anti-tumor.

Reference


Sharma A, Deo AD, Riteshkumar ST, Chun TI, and Das A. (2010). Effect of Withania somnifera (L. Dunal) root as a feed additive on immunological parameters and diseases resistance to acromonas hydrophila in labeo rohita (Hamilton) fingerlings. Fish and shellfish immunology 29; 508-512


ICCBES-1299
Isolation, Characterization and Screening for Anticancer and Antimicrobial Properties of the Crude Extract from Genus Neosartorya

Supattara Poeaim*, Kongluekai Tongkantom, Prapaiporn Jabamrung, On Bo-kaew and Mayamor Soytong
Department of Biology, Faculty of Science, King Mongkut’s Institute of Technology Ladkrabang, Bangkok, Thailand
poeaim@hotmail.com

Abstract
The genus Neosartorya, the sexual states of Aspergillus, belongs to the Eurotiales which have been reported for compounds with bioactivities such as antimicrobial, antimalarial and cytotoxicity. The objective of this research was to isolate, identify and screening for anticancer and antimicrobial properties of the ethyl acetate crude extract from Neosartorya. Neosartorya sp. were isolated from soil in Chiang Mai province, Thailand by the soil plate technique. The samples were identified based on morphology and DNA sequencing: Internal transcribed spacer (ITS), β-tubulin and calmodulin as Neosartorya hiratsukae and Neosartorya pseudofischeri. For in vitro cytotoxicity activity by MTT assay using eight cell lines (MCF-7, P388, HeLa, Vero, L929, KB, HT-29 and HepG2). The crude ethyl acetate extract of N. hiratsukae and N. pseudofischeri showed the highest potency against the L929 cell line with the 50% inhibitory concentration (IC50) value of 144.31 and 267.73 µg/ml, respectively. The antimicrobial properties of crude extract was evaluated using disc diffusion method against five bacteria strain: Bacillus subtilis, Staphylococcus aureus, Micrococcus luteus, Escherichia coli and Pseudomonas aeruginosa. The extract was well inhibited the growth of gram positive pathogenic bacteria: B. subtilis, S. aureus and M. luteus. The results indicate its possible potential with the production of other bioactive agents for future anticancer and antibiotic drug development.

Keywords: Antimicrobial, Cytotoxicity, Neosartorya hiratsukae, Neosartorya pseudofischeri

1. Background/ Objectives and Goals
The genus Neosartorya belongs to Trichocomaceae family under the order Eurotiales. These fungi are perfect state (teleomorphic stage) of Aspergillus. Some species of the genus Neosartorya have been reported for compounds with bioactivities such as antibacterial and cytotoxicity. For example, three new compounds isolated from the Neosartorya pseudofischeri inhibited the growth of six human cancer cell lines that a quinazolinone displayed cytostatic effects in human U373 glioblastoma and A549 non-small cell lung cancer apoptosis-resistant cells with marked inhibition of mitotic rates (Eamvijarn et al., 2012). New compounds, a
pyrroloindole and fischerindoline, inhibited the growth of six human and mouse cancer cell lines (Masi et al., 2013). Including, a new meroterpenoid: tatenoic acid was isolated from the fungus *N. tatenoi* exhibited cytotoxicity against human small cell lung cancer (NCI-H187) and human epidermoid carcinoma in the mouth (KB) (Yim et al., 2014). Additionally, the crude mycelial extracted from *N. spinosa* were reported as antibacterial (Sanmanoch et al., 2013). The screening for bioactive compounds from the *Neosartorya* is challenging. Therefore, this research focuses on isolation and identification of *Neosartorya* from the forest soil in Thailand and screening for anticancer and antimicrobial properties.

### 2. Methods

#### 2.1 Fungus isolation and morphological characterization

The genus *Neosartorya* were isolated from soil collected at Doi Suthep and Doi Inthanon mountains (Chiang Mai, Thailand). The soil samples were cultured on glucose ammonium nitrate agar (GANA) by soil plate technique (Soytong, 1992). Then, single colony of *Neosartorya* was transferred to PDA for purification. The fungi were grown on PDA about 2 weeks at 25°C for morphological characterization. The identification was done by observation of colony and mycelia morphology, cleistothecia, asci and ascospore using light microscopy and scanning electron microscopy (Soytong, 1992; Domsch and Gams, 1993).

#### 2.2 DNA extraction, amplification and sequencing

Fungal genomic DNA was obtained from 10-15 days old culture mycelia of the potato dextrose broth medium (PDB) and genomic DNA extracted using the standard CTAB method. The ITS ribosomal DNA regions were amplified by PCR using the universal primers, ITS1 and ITS4 (White et al., 1990). The β-tubulin gene was amplified using the Bt2a and Bt2b (Hubka and Kolarik, 2012) and the calmodulin gene was amplified using the CF1L and CF4 primers (Peterson, 2008). The PCR products were purified with PCR purified kit (Vivantis, USA). Sequencing was performed at First Base Laboratories, Malaysia. The obtained nucleotide sequences were searched through BLASTN at GenBank database (http://www.ncbi.nlm.nih.gov/BLAST).

#### 2.3 Fungal culture and extraction

The mycelium were taken by vertically cutting 6 mm diameter plugs using a cork borer. The plugs were transferred to 250 ml bottles containing 10 ml of PDB and incubated at room temperature for 1 month. The culture was harvested by filtration through several layers of gauze and mycelia were collected and dried at 45°C for 3 days. The powdered mycelia were extracted with ethyl acetate on a rotary shaker (120 rpm) for 3 days at room temperature and repeated for 3 times. The supernatants were filtered through a Whatman filter paper No. 1 and concentrated using a rotary evaporator at 40°C. The crude extracts were kept in dark bottles under refrigerated conditions until the time of experiment.
2.4 Determination of anticancer activity
The HT-29 (Human colon adenocarcinoma), MCF-7 (Human breast carcinoma), P388 (Murine leukemia), L929 (Murine fibroblasts) and Vero (African green monkey kidney) cell lines were a kind gift from Dr. Porntipa Picha, Research Division, National Cancer Institute, Bangkok. The KB (Human mouth epidermal carcinoma), HeLa (Human cervical carcinoma) and HepG2 (Human hepatocellular carcinoma) cell lines were obtained from Scientific Instruments Centre, Faculty of Science, King Mongkut’s Institute of Technology Ladkrabang, Bangkok. The KB cells were maintained in RPMI 1640 medium with 10% (v/v) fetal bovine serum (FBS) and 0.05 µg/ml gentamicin in 5% CO₂ humidified incubator at 37°C. The MTT assay proposed by Mosmann (1983) was modified and used to determine antiproliferative activity of extracts. Briefly, exponentially growing cells were seeded onto a 96-well plate and allowed to attach for 24 hours before treatment. The crude extracts were dissolved in dimethyl sulfoxide (DMSO) and sterilized by filtration through 0.22 µm filter. Cells were treated with 100 µl of those crude extracts within a range of final concentrations from 125 to 2000 µg/ml for 20 hours. The fifty microliters of MTT solution (2 mg/ml in phosphate buffer saline) were added to each well and further incubated for 4 hours at 37°C. All the exposure conditions were tested in triplicate and observed for cell morphological analysis. After the reaction, the supernatant were removed and replaced with DMSO: ethanol (1:1 v/v) to solubilized formazan crystals. The absorbance was measured at 570 nm using a microplate reader (Anthos MultiRead 400, Biochrom, UK). The percentage of inhibition of cell growth was calculated and the 50% inhibitory concentration (IC₅₀) was estimated using GraphPad Prism 5 software.

2.5 Determination of antimicrobial activity
The extracts were tested using agar disc diffusion described by Ansari et al. (2005). Five microbial strains: Bacillus subtilis, ATCC6633, Micrococcus luteus ATCC9341 and Staphylococcus aureus TISTR1466 and two gram negative bacteria (Escherichia coli ATCC25922 and Pseudomonas aeruginosa ATCC27853 were cultured in Mueller-Hinton Broth (MHB) and incubated at 37°C for 4-5 hours. The optical density of cells was adjusted to 0.5-0.8 at 600 nm. Each bacterial suspension was swab over the surface of Mueller Hinton Agar (MHA) with a sterile cotton swab. Various concentrations of extracts (0.20, 0.5, 1 and 2 µg/disc) dissolved in methanol were loaded onto the 6 mm sterile paper disc, then were placed on the agar. Methanol and 100 µg/ml gentamicin were used as negative and positive control, respectively. Incubated at 37°C for 24 hours, the diameters of the inhibition zone were measured.

3. Results and Discussion
3.1 Isolation, morphological and DNA sequencing characterization
The morphological features were observed as microscopic characters which showed white to creamy colony and cleistothecia, ascospores are globose to broadly ellipsoidal with equatorial furrow and ridges identified as Neosartorya. One isolate (EU06) had a creamy-white colony, cleistothecia are globose (90.7-263.05x91.98-276.76 µm), ascus are globose (9.86-13.63x8.63-13.9 µm) and ascospores are broadly ellipsoidal (3.86-6.81x3.70-6.48 µm) with two equatorial crests (Fig. 1). The other (EU13) had a white colony, cleistothecia are globose (274.44-506.11x301.43-526.58 µm), ascus are subglobose (10.70-12.03x11.23-12.08 µm) and ascospores are subglobose (3.54-5.53x4.30-5.59 µm) with narrow equatorial furrow (Fig. 2). These indicate that identification of Neosartorya sp. not easy based on morphology. Therefore, we further analyzed DNA sequence of the three region and combined the data with morphological characteristic in order to confirm species. The nucleotide sequences were compared with BLASTn in NCBI Genbank. The three region were amplified that related to the two species. For EU06, the fragments for ITS, β-tubulin and calmodulin were 606, 545 and 735 bp, respectively identified as N. hiratsukae. For EU13, the fragments for ITS, β-tubulin and calmodulin were 588, 553 and 764 bp, respectively identified as N. pseudofischeri. The dendrogram of calmodulin gene was demonstrated representative of these fungi (Fig. 3). Our result was supported with findings of Sanmanoch et al. (2013) who reported the nucleotide sequences from the ITS region is useful and suitable for Neosartorya identification. However, identification of Neosartorya should be use both molecular and morphological techniques (Hong, et al., 2006).

3.2 Anticancer activity
Antiproliferative activity of ethyl acetate extract of N. hiratsukae and N. pseudofischeri were determined using the MTT assay in eight cell lines (HT-29, MCF-7, P388, L929, Vero, KB, HeLa and HepG2) at concentration ranging from 125 to 2000 µg/ml. Pretreatment with MTT solution, the cells treated with extract were irregular, round shape and some cells were detached from the culture surface when observed under inverted phase contrast microscope. The crude extract of N. hiratsukae exhibited antiproliferative activity against the top three cell lines; L929, Vero and HeLa, respectively. The ethyl acetate extract of N. pseudofischeri shown against the top three cell lines; L929, HeLa and HT-29, respectively. The results also show that L929 cell line was the most sensitive to the N. hiratsukae and N. pseudofischeri extracts with IC50 values are 144.30 and 267.73µg/ml, respectively (Table 1). Our findings are consistent with the some species of the genus Neosartorya such as N. pseudofischeri, N. tatenoi and N. spinosa have been reported for compounds which potent cytotoxicity against the mammalians and insect cell lines (Eamvijarn et al., 2012; Masi et al., 2013; Sanmanoch et al., 2013; Yim et al., 2014; Lan et al., 2016).
Figure 1 Morphological features of *Neosartorya hiratsukae*, A-B: Colony grown on PDA for 15 day at 25°C, C-D: Cleistothecia, E: Asci exposed from cleistothecium, F: Ascus, G-H: Ascospores observed under light microscope and I: Ascospores as seen by SEM. Bars, 100 μm (D) and 10 μm (E-H).

Figure 2 Morphological features of *Neosartorya pseudofischeri*, A-B: Colony grown on PDA for 15 day at 25°C, C-D: Cleistothecia, E: Cleistothecium, F: Asci, G-H: Ascospores observed under light microscope and I: Ascospores as seen by SEM. Bars, 100 μm (D), 20 μm (E) and 10 μm (F-H).
3.3 Antimicrobial activity

The crude ethyl acetate extract of *N. hiratsukae* and *N. pseudofischeri* showed antimicrobial activity against three of five tested human pathogenic bacteria. No inhibitory activity against *E. coli* and *P. aeruginosa* was observed. Crude extracts from *Neosartorya* showed well inhibited the growth of gram positive bacteria (*B. subtilis*, *S. aureus* and *M. luteus*) (Table 1). Our result was supported with findings of Sanmanoch et al. (2013) who reported to the antibacterial activities of crude ethyl acetate extract from *N. spinosa* KKU1NK1 most strongly inhibited the growth of gram positive pathogenic bacteria (*S. aureus*, *S. saprophyticus*, *S. pneumonia* and *B. subtilis*).
4. Conclusion

The genus *Neosartorya* were isolated from forest soil collected at Doi Suthep and Doi Inthanon mountains, Thailand. Identification of *Neosartorya* species are not necessarily based on morphology, it should be used both morphological characterization and molecular methods. Screening for its bioactive compound, the crude ethyl acetate extract of the *N. hiratsukae* and *N. pseudofischeri* were analyzed to eight different mammalian cell lines which showed potent cytotoxic effect in some cell lines. Additionally, the crude extracts inhibited the growth of gram positive bacteria. Our findings provide further evidence that the fungus *Neosartorya* has the tremendous potential of biosynthesis. Therefore, our attempts to isolate *Neosartorya* from different place or sources and screening for their bioactivities in order to development as an anticancer and antibacterial drug.

5. Acknowledgements

We would like to thank Assoc. Prof. Dr. Kasem Soytong for his comments and criticizes our manuscript and thanks anonymous reviewers for their helpful comments on the manuscript.

6. References


Optimization for Callus Induction and Plant Regeneration from Mature Seeds of Thai Rice Variety: Nam Roo (Oryza sativa L.)

Anurug Poeaim*, Supattra Poeaim, Ranyikar Poraha, Saengthong Pongjaroenkit and Pradit Pongthongkam

*Department of Biology, Faculty of Science, King Mongkut’s Institute of Technology Ladkrabang, Bangkok, 10520, Thailand

Department of Genetics, Faculty of Science, Maejo University, Chiang Mai, 50290, Thailand

Thepstri Rajabhat University, 321 Naraimaharat Road Tambon Talaychubsorn Amphur Muang, Lopburi, 15000, Thailand

anurug@hotmail.com

Abstract

The aim of this study was to develop a productive protocol for optimum callus induction and regeneration of Thai rice variety: Nam Roo (Oryza sativa L.). Callus were induced on MS (Murashige and Skoog) and NB (Nitsch and Nitsch) media supplemented with 0.5 mg/l NAA (α-Naphthaleneacetic acid) and 0.5, 1, 2, 3 and 5 mg/l 2,4-D (2,4-Dichlorophenoxyacetic acid) in different concentrations, 1 g/l L-proline, 30 g/l sucrose and 2.6 g/l phytagel. Nam Roo gave its maximum mean size (391.49 mm³) and mean weight (0.3412 g.) of callus on NB medium supplemented with 1 mg/l 2,4-D for 4 weeks. For plant regeneration the callus were cultured on MS and NB media containing with 0.5 mg/l NAA and different concentrations of 1, 2 and 3 mg/l BAP (6-Benzylaminopurine), 30 g/l sucrose and 2.6 and 5.2 g/l phytagel. The highest regeneration frequency (%) was grown on MS medium composed of 2 mg/l BAP in 5.2 g/l phytagel. It took 6 weeks for the callus to regenerate into a complete plate. Then the plantlets were transferred into the plastic pot.

Keywords: Nam Roo (Oryza sativa L.), Callus induction, Plant regeneration

1. Background/ Objectives and Goals

Rice (Oryza sativa L.) is one of the most important cereal crops which supplies food for more than half of the world’s population. However, rice yield and quality are affected by pests and diseases, as well as by environmental stress. And the increasing world population, the value of and demand for this crop will also steadily rise. Therefore, the techniques of biotechnology are very important for developed to increase productivity and quality of rice. Tissue culture has played an increasingly important role in rice improvement in recent years. Thai rice variety: Nam Roo (Oryza sativa L.) is non-glutinous rice and it is indigenous upland rice, it was collected from seeds of Lisu hill tribe at Chiang Dao district, Chiang Mai, Thailand. Nam Roo is photoperiod sensitive and resistance to blight disesses, approximately 141 cm in height and
provides and average yield of 247 kg per hectare. When cooked, the grains have a light and fluffy texture. (Bureau of Rice Research and Development). The embryogenic callus can be induced from tissues of various organs such as immature and mature embryo, leaf blade and root for rice breeding, has made higher yield, improved quality of local rice. For plant regeneration from an embryogenic callus, the somatic embryo is an intermediate stage between the undifferentiated callus and seedlings. It is a differentiated and meristematic form of a somatic (callus) cell developed through a series of complex morphological and cellular changes (Laux and Jurgens, 1997; Helariutta et al., 2000; George et al., 2008; Ikram-ul-Haq et al., 2009). So, the aim of this study was to develop a productive protocol for optimum callus induction and plant regeneration of thai rice variety: Nam Roo (Oryza sativa L.)

2. Methods

Explants preparation
The dehusked mature seeds of thai rice variety: Nam Roo (Oryza sativa L.) were obtained from Samoeng Rice Research Center, Chiang Mai Province, Thailand. Mature seed were surface-sterilized in sterile distilled water for 1 minute and 70% ethanol for 1 minute, then shaking in 20% Sodium hypochlorite for 30 minutes and finally rinsing three times in sterile distilled water. The mature seeds were dried on the plate containing sterilized filter papers.

Callus Induction
Mature seeds of Nam Roo were cultured on MS (Murashige and Skoog, 1962) and NB (Nitsch and Nitsch, 1969) media supplemented with 0.5 mg/l NAA (α-Naphthaleneacetic acid) and different concentrations 0.5, 1, 2, 3 and 5 mg/l 2,4-D (2,4-Dichlorophenoxyacetic acid) respectively, 1 g/l L-proline, 30 g/l sucrose and 2.6 g/l phytagel. The pH of media was adjusted at 5.8 prior to autoclaving at 121 °C for 15 minutes. Cultured mature seeds maintained in the dark condition at 25±2 °C. After 4 weeks, the frequency of callus induction (%), mean size and mean weight of callus formation were calculated. Data on callus induction were analysed using the SPSS 20. Analysis of variance (ANOVA) was used for comparing means and Duncan’s multiple range test was further analysed when significant difference were found at P level of 0.05.

Plant regeneration
Plant regeneration of Nam Roo callus were separated two parts. Firstly, the callus (fresh) was directly transferred to regeneration media. Secondly, the callus were dried on the sterilized Petri dishes and incubated under dark condition for 7 days. After that, the callus (dry) was cultured on regeneration media. Both parts were cultured on regeneration media. The media was MS and NB media containing with 0.5 mg/l NAA and different concentrations of 1, 2 and 3 mg/l BAP (6-Benzylaminopurine) respectively, 30 g/l sucrose and 2.6 and 5.2 g/l phytagel. The pH of media was adjusted at 5.8 prior to autoclaving at 121 °C for 15 minutes. The fresh and dry callus
were incubated at 25±2 °C under light condition for 6 weeks. After culture, the number of calli forming shoots and the number of shoots per callus were counted to determine for plant regeneration. Then the plantlets were transferred into the plastic pot.

3. Results

3.1 Callus Induction

The experiments were made to determine the suitable of MS and NB media and different concentration of 2,4-D for callus induction of Nam Roo rice. Callus were induced on MS and NB media supplemented with 0.5 mg/l NAA and 0.5, 1, 2, 3 and 5 mg/l 2,4-D in different concentrations after 4 weeks. The results show that mature seeds were induced to callus in all media. The frequency of callus induction amount 100% in all media is shown in Table 1. The callus was induced formed mostly embryogenic callus, which creamy, dry and compact appearance. A similar was reported by Ghobeishavi et al. (2015), that found embryogenic callus were yellowish white, compact and nodular in the Nemat and Domsiah rice varieties. In this study, combination effects of both media (MS and NB) and concentration of 2,4-D were tested. By analysis of variances for the callus cultured on NB medium grew at higher rate than cultured on MS medium. Considered from means size and means weight of callus in (Table 1 and Figure 1). Nam Roo gave its maximum mean size (391.49 mm³) and mean weight (0.3412 g.) of callus on NB medium supplemented with 1 mg/l 2,4-D. (Table 1, Figure 1 and Figure 2). A similar with Rattana et al. (2012) reported that the optimal concentration of 2,4-D for Pathum Thani 1 were 1 mg/l in NN medium (Nitsch and Nitsch, 1969), the average size of calli were 1.06 cm. and the average fresh weight of calli were 0.35 g.
Values followed by different letters indicating significant differences according to Duncans’s Multiple Range Test (p≤0.05)

0.35 g. As though Gnanesh et al. (2012) presented 1 mg/l 2,4-D induced better callogenic response in both cultivar of rice: Karimundaga (94%) and Kanadatumba (58%). The difference in the composition of medium can result in variation in callus induction (Torbet et al., 1998). NB medium composed of nitrogen sources as N6 medium and PP medium (Poonsapaya et al., 1989) as recommended by Rueb et al. (1994). It is perhaps due to the reason that NB medium contained more nitrogen than the MS medium. And auxin is most commonly used to induce callus formation (Htwe et al., 2011). However, the optimal concentration of 2,4-D depend on
the explants and genotypes of rice (Raina, 1987).

### 3.2 Plant regeneration

For plant regeneration, the fresh callus and dry callus were cultured on MS and NB media with 0.5 mg/l NAA and 1, 2 and 3 mg/l BAP in 2.6 and 5.2 g/l phytagel. The regeneration was appeared green spot on callus about 14 days of transfer to regeneration media and roots were grown from the callus at the same time (Fig. 2A, 2B). Sahrawat and Chand (2001) reported that shoot bud started from nodular green spots after transferred to regeneration medium. Shoot regeneration was grow and elongated after 4 weeks (Fig. 2C, 2D). After cultured for 6 weeks, the frequency (%) of regeneration of fresh callus and dry callus obtained from media containing 0.5 mg/l NAA, combination with 1, 2 and 3 mg/l BAP in 2.6 and 5.2 g/l phytagel were presented in Table 2. The result showed the highest frequency of plant regeneration (100%) was 2 mg/l BAP and 0.5 mg/l NAA in 5.2 g/l phytagel of dry callus. Shoot and root were completely induced (Fig. 2E, 2F). Karthikeyan *et al.*, (2009) reported that in a recent report it has been mentioned that plant regeneration was achieved through embryogenic callus on MS medium supplemented with different concentrations of BAP and NAA. Similarly, the presence of BAP and NAA was found the suitable for somatic embryo germination in rice MR219 (*Syaiful et al.*, 2009). They reported that 82.5% of the somatic embryos were grown into the seedling upon transferring the somatic embryos on the MS medium with 2 mg/l BAP and 0.5 mg/l NAA. The addition of BAP to the regeneration medium was important for shoot induction from callus Toppo *et al.*, (2014). The data was
shown in the Table 2 that between fresh callus and dry callus were different percentages of regeneration. The dry callus was developed to shoot more than fresh callus. And, at result observed that shoot in 5.2 g/l phytogel were higher than 2.6 g/l phytogel. Similar to Kaur and
Gosal (2009) presented that the desiccation created by using agar caused increasing in regeneration frequency of sugarcane callus. Regenerated plantlets were hardened and transferred to the soil in the plastic pots within 6 weeks (Fig. 2G). From the present study, it could be concluded that callus induction frequency was found better on NB medium. The maximum mean size and mean weight of callus induction were cultured on NB medium supplemented with 1 mg/l 2,4-D. The highest regeneration frequency (%) was grown on MS medium composed of 2 mg/l BAP in 5.2 g/l phytagel. The regenerated plants had normal growth after transferred into the plastic pot. The method presented here will be useful in biotechnological approaches to improve rice through \textit{in vitro} induced artificial mutations using radiation such as X-ray, gamma-rays and ion.

3.1 Acknowledgments and Legal Responsibility
This research paper was supported by the Office of the Higher Education Commission Thailand and Department of Biology, Faculty of Science, King Mongkut’s Institute of Technology Ladkrabang, Bangkok, Thailand.

4. References
ICCBES-1265
Utilization of Meat and Waste from Sandfish (Holothuria Scabra)
Environmentally Friendly for Anti-Aging Source Material for Elderly Woman

*Etty Riani¹, Chairunissa², Hera Maheswari², Muhammad Dzikrifishofa³
¹Department of Aquatic Resources Management, Faculty of Fishery and Marine Science, Bogor Agricultural University
²Faculty of Veterinary Medicine, Bogor Agricultural University
³Regional General Hospital of Leuwiliang, Regency of Bogor
⁴Study Center of Biopharmaca, Institute of Research and Community Services – Bogor Agricultural University
*E-mail: etty_riani_harsono@yahoo.com

Abstract
Sandfish is one of the important economically valuable commodities of fisheries, and traded without any added value. Sandfish contain steroid that can act as an anti-aging in menopausal women, so its commercialization value can be very high. Unfortunately, the sandfish source material is still taken from the wild, which indicates an overexploitation, so its utilization needs to find a way to keep preserve the sandfish in the nature. The study was aimed to get the size of sandfish that contained high steroid for anti-aging needs, but can still support its sustainability in the nature. The sandfish used in this study had a size of less than 10 cm, 10–15 cm and more than 15 cm. In the meat and innards of the sandfish, the qualitative steroid test was conducted using Lieberman Burchard Test, and the quantitative test done by extracting the steroid using acetone. The result showed that from the quantitative test in the sandfish with a size of < 10 cm the steroid content was not yet discovered in the meat and innards, in the sandfish of 10-15 cm the steroid was found in a small amount, and in the sandfish of > 15 cm it was found in a large amount. In the steroid extraction using acetone, the steroids from the meat and the innards of the sandfish with a size of < 10 cm were not detected, while in the sandfish of 10-15 cm the steroid contents were 2.18 g/kg and 3.68 g/kg, respectively, and in the sandfish of >15 cm the contents were 10.02 g/kg and 13.68 g/kg, respectively. The productive period of the sandfish is on the length of 18-27 cm (Riani, 2011). Therefore, to get the sandfish with a high steroid content, so that potential to be the raw material of anti-aging for elderly women, but it has already spawned several times, so that giving a chance for them to breed, making it environmentally friendly and also making it easy in handling of making the anti-aging product, then the length of sandfish used as the raw material of anti-aging is more than or equal to 27 cm.

Keywords: meat and waste of sandfish, steroid, overexploitation, environmentally friendly, anti-aging, elderly women
Introduction

Background
The women who enter the menopause stage generally are susceptible to various diseases such as osteoporosis, at risk to obesity and high cholesterol, easily experience fractured bones, skin becomes wrinkled and less supple, as well as many other medical problems. Therefore, the menopausal women generally take various efforts to prevent the occurrence of such problems. One of the efforts done is through the hormone therapy (Thompson & Maibach, 2010), considering the cause of these problems, according to Thompson et al. (2000), is the result of the decrease of estrogen hormone production. This is in line with the opinion of Hansen (2008) that estrogen hormone plays a role in inhibiting the aging process, and prevents the woman’s body from going into the menopause stage.

The hormonal therapy in order to prevent the occurrence of menopause generally uses the synthetic estrogen (Thompson & Maibach, 2010), synthetic testosterone (Sherwood, 2001) or methyl testosterone combined with the synthetic estrogen (Salbilal, 2006). This therapy is proven to treat symptoms of early aging, and keep the body of elderly woman to stay fit, but often brings the side effects that cause problems of its own (negative side effects). According to Riani et al. (2005, 2006, 2007) and Riani (2010), in the meat and waste of sandfish, there’s a testosterone that has a potential to be an aphrodisiac and sex reversal material that is safe for consumption and also environmentally friendly. Furthermore, these studies also proved that the fresh sandfish have a higher potential in producing the steroid hormone compared with the dried one. This material is potential as TSH in menopause and post-menopause treatments (Riani et al., 2010). The result of study by Riani et al. (2015) also showed that steroid from sandfish has a potency as anti-aging for elderly women. But, whether all sandfish in various sizes have potential to be used as an anti-aging in elderly women, as well as which part of the body of sandfish that can be utilized for this purpose and which size of sandfish with the most potential as an anti-aging, the information is still minimal, so it needs to be observed which size and which part of the body can be utilized as a source of raw material of anti-aging for elderly women. The aim of this study is to get the size of sandfish with high steroid content for anti-aging need, but also can support the sustainability of sandfish in the nature.

Method of Study
The sandfish used in this study were obtained from Lampung Waters. The sandfish used were fresh sandfish with various sizes, those were less than 10 cm, 10-15 cm and more than 15 cm. The part of the body used were the meat and the innards of sandfish which were the wastes of sandfish product.
In the meat and innards of the sandfish, the qualitative steroid test was conducted using Lieberman Burchard test. In this test, the former extraction of steroid from the meat and the innards of sandfish using acetone was done. Subsequently, a few drops of acetic acid anhydride and 0.5 ml chloroform were added into the two extracts of three groups of sandfish size, stirred, and then one drop of concentrated sulfuric acid was also added into these. The presence of the steroid content is characterized by the formation of green color in the extract (Cook, 1958; Bahtiet et al., 1983; Harborne, 1987).

The quantitative steroid test (testosterone) in the meat and the innards of sandfish from these three groups of sandfish size was carried out using the technique of $^{125}$I radioimmunoassay on the extract sample dissolved in corn oil, by using total testosterone of Coat-A-Count, catalog number TKTT1. The principle of the procedure was based on the competition between the testosterone of the sample and the testosterone with $^{125}$I label to be bound to an antibody specific for testosterone. This quantitative steroid test was done in all three groups of sandfish size. The measurement procedure was conducted as performed by Riani et al. (2010). This quantitative steroid test was done in all three groups of sandfish size, which was measured on each dry weight of the meat and the innards of sandfish.

**Result and Discussion**

**Identification of Steroid Presence**

Identification of steroid presence in the meat and the innards of sandfish through the qualitative steroid test shows the results presented in Table 1. The result of qualitative test in sandfish with a size less than 10 cm, both in the meat and innards relatively did not show a green color formation during titration using concentrated sulfuric acid. This was interpreted as no steroid had been found. However, the qualitative steroid test in sandfish with a size of 10-15 cm, both in the meat and the innards, had already indicated that there were steroids showed by light green color. This green color formation was defined as the presence of steroid that relatively in a few amount. It was different with the result obtained from the sandfish with a size over 15 cm which showed that both in the meat and the innards of the sandfish, the formation of dark green color occurred. This was identified as the greater amount of steroid content.
Steroid Content in the Meat and the Innards of Sandfish

In the quantitative steroid test, which was represented by the testosterone derived from the meat and the innards of sandfish using the $^{125}$I radioimmunoassay technique, showed a result that in the meat and the innards of small-sized sandfish (offsprings) with a body length less than 10 cm, on average the steroid had not been detected. This was because the sandfish with a size less than 10 cm had the genitals that were still immature that they had not been able to perform the reproduction process or in other words had not produced steroid hormones (Riani, 2011) (Tabel 2).

In the quantitative steroid test of the sandfish with a size of 10-15 cm, the meat and the innards contained the steroid on average by 2.18 g/kg and 3.68 g/kg, respectively. The mainly reason of this occurrence was the sandfish with the size around 15 cm had already entered the mature sexual criterion (Riani, 2011), so that the sandfish were able to produce steroid hormone. However, the amount was still relatively small.

In the quantitative steroid test of the sandfish with a body length size more than 15 cm, it was obtained that the meat and the innards of the sandfish contained steroid hormone on average by 10.02 g/kg and 13.68 g/kg, respectively. This is in line with the study result of Riani (2011) that the productive lifetime of the sandfish is on the body length of 18-27 cm. Therefore, the sandfish with a size of 18-27 cm is potential to be a raw material of anti-aging for elderly women. However, according to Riani (2011) the sandfish with a size less than 25 cm is the sandfish that has already had the chance to spawn more than once, so its utilization in addition to produce the steroid relatively large in amount, it also gives the opportunity to the sandfish to reproduce first. Thus, the use of sandfish with a size of 25 cm or more is relative to become more environmentally friendly, and in the handling, it is also easier to produce the anti-aging product.
Related to this, the length of the sandfish used as raw materials for anti-aging even will be more environmentally friendly if the length of the sandfish used is equal to or more than 27 cm.

Table 2. Averages of steroid content in the meat and the waste of sandfish with different length sizes

<table>
<thead>
<tr>
<th>No.</th>
<th>Sample</th>
<th>Steroid concentration (g/kg dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sandfish with a size &lt;10cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Meat</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>- Innards</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Sandfish with a size of 10-15 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Meat</td>
<td>2.18</td>
</tr>
<tr>
<td></td>
<td>- Innards</td>
<td>3.68</td>
</tr>
<tr>
<td>3</td>
<td>Sandfish with a size &gt;15 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Meat</td>
<td>10.02</td>
</tr>
<tr>
<td></td>
<td>- Innards</td>
<td>13.68</td>
</tr>
</tbody>
</table>

Conclusion and Suggestion

1. The sandfish with a size more than 15 cm is potential to be used as raw material of anti-aging for elderly women.
2. The innards that are categorized as the sandfish waste have a higher potential to produce steroid used as anti-aging.
3. For the purpose of more environmentally friendly utilization of sandfish, the ideal size of the sandfish used as raw material of anti-aging product for elderly women is equal to or more than 27 cm.

References


Salbilal A. 2006. Terapi Sulih Testosteron. Faculty of Medicine. Airlangga University. LPPM Unair (Institute of Research and Community Services of Airlangga University). unair.ac.id


ICEAI-1105
Hybrid Trust-Aware Content Placement Scheme for Wireless Mesh Network in the Disaster Area
Yong-Jun Seo | Korea Advanced Institute of Science & Technology
Sang-Hyun Lee | Korea Advanced Institute of Science & Technology
Eun-Jung Lee | Korea Advanced Institute of Science & Technology
Hong-Shik Park | Korea Advanced Institute of Science & Technology

ICEAI-1183
Nonlinear Saturable Absorbers based on Graphene Directly Synthesized onto Device Surface with Telecom Laser
Pulak C. Debnath | Korea Institute of Science and Technology
Jaehyun Park | Korea Institute of Science and Technology
Yong-Won Song | Korea Institute of Science and Technology

ICEAI-1192
Design of Fractional Order Model Reference Adaptive Controller
Ozkan Atan | Yuzuncu Yil University
Mustafa Turk | Firat University

ICEAI-1203
Grid Tied Fuel Cell System Using Single Phase PLL Based SOGI with PI and PR Current Controllers
M.Emin Meral | Yuzuncu Yil University
Doğan Çelik | Yuzuncu Yil University
ICEAI-1207
Highly Sensitive Airgap Fiber Fabry-Pérot Interferometer Based on Multilayer Dielectric Thin Film Coated on the Fiber Endfaces
Wei-Chieh Lee | National United University
Nai-Jie Huang | National United University
Cyun-Lun Zeng | National United University
Fan-Bean Wu | National United University
Cheng-Ling Lee | National United University

ICEAI-1196
Measurement of Temperature Dependent Thermal Expansion Coefficient of Polymer in a Microcavity Hollow Core Fiber Fabry – Pérot Interferometer
Hsiu-Yu Fan | National United University
Shih-Hsiang Lu | National United University
Jheng-Hong Gu | National United University
Cheng-Ling Lee | National United University
Hybrid Trust-Aware Content Placement Scheme for Wireless Mesh Network in the Disaster Area

Yong-Jun Seo, Sang-Hyun Lee, Eun-Jung Lee, Hong-Shik Park
School of Electrical Engineering, KAIST, Daejeon, Republic of Korea
E-mail address: {yongjun86, capricorns, freakone, park1507}@kaist.ac.kr

Abstract
Recently, a wireless mesh network (WMN) with the characteristics of self-organization and easy configuration becomes an emerging solution to suit for disaster recovery. In the disaster area, fast and reliable dissemination of the information required for disaster response is one of the most important functions for disaster recovery. To do that, an appropriate content placement scheme considering various circumstances is inevitable. Most of previous researches have only considered either a physical network metric or a logical network metric. In this paper, we define a new trust level using the two metrics which are the betweenness centrality as the logical network metric and the energy increasing rate as the physical network metric. Based on the defined trust level, we propose the Hybrid Trust-aware Content Placement (HTCP) scheme for WMN. The simulation results show that our proposed HTCP scheme outperforms existing methods for enhancing network throughput while reducing the end-to-end delay in the disaster area.

Keywords: Wireless mesh network, betweenness centrality, energy increasing rate, trust level, content placement

4. Introduction
Recently, a wireless mesh network (WMN) receives much attention as a technology to recover a disaster area as various natural disasters (i.e. earthquake, tsunami, tornado, and fire) frequently occur around the world [1-3]. According to the recent report in [4], 6,873 natural disasters are reported and 1.35 million people died in the last 20 years. In 2015, the great earthquake hit Nepal, which claimed more than 7,000 people lives and injured more than 14,000 people. To recover the communication network in such disasters, some previous works on post-disaster networks in [5-7] have been done during the recent several years. According to [1-3], WMN is suitable to these situations among various networks because it can ensure wide service coverage and be easily installed without a wired connection between network nodes with the characteristics of self-healing, self-organization, and self-forming.

Together with the network recovery issue, fast and reliable dissemination of the information is also an important issue for the disaster area. For this dissemination, most previous researches
only used the traditional communication methods such as telephone and text notification. Although the previous works are helpful to disseminate the information required for disaster response, they are a little bit slow and hard to support the high quality information such as video. According to nowadays researches in [8, 9], most of people tend to spread the information about disaster using a social network service so quickly and widely, which requires high bandwidth to the communication networks. Such enormous bandwidth usage causes the serious performance degradation in this disaster area. As a result, it may lead to deterioration of the information dissemination speed. Accordingly, to deal with the above disaster situation effectively, it is significant not only to configure the recovery network quickly but also to select the proper content caching node which can quickly and efficiently disseminate the important information to everyone.

To overcome this limitation, several researches on efficient data/traffic distribution using WMN in the disaster area have been made. The previous works can be categorized in two approaches: network based approach and social based approach. The network based approaches in [10, 11] tried to distribute data effectively using the physical information. The authors in [10] proposed a location based routing algorithm for WMN which slightly modified the existing routing messages to consider the location information. The authors in [11] proposed an efficient traffic distribution technique to avoid congestion at the gateways for disaster area communication using WMN. They considered balanced distribution of the bandwidth to be allocated per user and the varying bandwidth demands per gateway. Although this approach showed the better performance in terms of the average delay and packet delivery ratio, their approach is hard to transmit the disaster information effectively due to the lack of social relationship between the users in the disaster area. As a smart phone becomes more common, on the other hand, the social based approach in [12-15] tried to distribute data using the information related social network services. The authors in [12, 13] highlighted the need for social network services as a disaster response media, and the analysis of information spread related to disaster response using social network services has also been studied in [14, 15].

Although these approaches efficiently considered the relationship between users and data dissemination, they did not consider the characteristics of the physical network. In summary, all these researches only considered either WMN (i.e. physical network) or social network (i.e. logical network).

In this paper, we propose a Hybrid Trust-aware Content Placement (HTCP) scheme for WMN in the disaster area. For fast and efficient dissemination of the information, we take into consideration two kinds of trust metrics, betweenness centrality and energy increasing rate.

We use the concept of betweenness centrality to consider the characteristics of the logical
network representing the social network relationship, and use the concept of energy increasing rate to take into account the characteristics of the physical network representing WMN with selfishness. From those trust metrics which consider both logical and physical side, we assign the trust level of a node and finally select suitable content caching nodes for fast and efficient dissemination of the disaster information.

The rest of the paper is organized as follows. In Section 2, we describe the system model of the proposed HTCP scheme. In Section 3, we evaluate the performance of the proposed HTCP scheme using the NS-3 simulator. We conclude the paper in Section 4.

5. System Model

2.1 Overview of Our System Model

In this section, we propose a trust-aware content placement scheme which selects content caching nodes for disseminating information fast and efficiently to users in the disaster area.

Fig. 1 shows an example of infrastructure in the disaster area. As depicted in Fig. 1, we consider the scenario in the disaster area and assume that there are several portable mesh routers and mesh clients with social network service users. In this scenario, each portable mesh router is energy-constrained and we suppose that the energy profile is known in advance. More details are explained in Sec 2.2. Our proposed scheme consists of four stages: overlay network formation, betweenness centrality calculation, energy increasing rate calculation, and content caching node selection as shown in Fig. 2.
Stage 1. Overlay network formation
In this stage, users connected with social relation in the social network are mapped to devices in the physical network. Users are logically connected to each other in the form of a scale-free network, and the users randomly divided into several groups are physically connected to each mesh router in WMN.

Stage 2. Betweenness centrality calculation

![Flowchart Diagram]

*Fig. 2: The flow chart of the proposed scheme*

In this stage, we calculate the betweenness centrality of each user and then, derive the betweenness centrality of each mesh router from user’s betweenness centrality. The candidate nodes with the higher betweenness centrality value are selected for fast disseminating.

Stage 3. Energy increasing rate calculation
In this stage, we calculate the energy increasing rate of each mesh router as a trust metric for efficient dissemination of contents.

Stage 4. Content caching node selection using trust level
In this stage, we finally select content caching nodes for fast and efficient dissemination of contents using the trust level which is defined by both the social information and the energy information obtained in the previous stage.
2.2 Trust Metrics

In our proposed scheme, we consider two trust metrics for fast and reliable information dissemination to users, betweenness centrality and energy increasing rate.

2.2.1 Betweenness Centrality

Centrality associated with the concept of influence means the most important nodes in the network. It indicates the degree of a certain node that locates how closely to the center in the network. Among various centrality metrics, betweenness centrality is one of the most frequently used indicators of a node’s centrality in the social network. It measures the degree of a node which acts as a broker among other nodes. A node with high betweenness centrality means a large influence on the flow of communication within the social network. In addition, in many cases other users focus on the information of this node.

The betweenness centrality is calculated as follows [16].

\[ C_B(v) = \sum_{s,t \in V, s \neq t} \frac{\sigma_s(t)}{\sigma_s}, \]

where the set \( V \) of vertices represents nodes, \( \sigma_s \) is the total number of shortest paths from source node \( s \in V \) to destination node \( t \in V \), and \( \sigma_s(t) \) is the number of shortest paths from node \( s \) to node \( t \) through node \( v \in V \).

In our proposed scheme, we sort several candidate nodes which could be a content caching node according to the betweenness centrality value \( r_{BC} \).

For this, we first calculate the betweenness centrality of all users by social network analysis. Then, we calculate the betweenness centrality of all mesh routers in the physical network. In this paper, we assume that the betweenness centrality of a mesh router in the physical network is the sum of the betweenness centrality values of all users who are mapped to that mesh router.

The value is normalized to have the \( r_{BC} \) from 0.0 to 1.0. After that, we select top-\( k \) candidate nodes for content caching with higher betweenness centrality value than the average of the betweenness centrality values of all mesh routers.

2.2.2 Energy Increasing Rate

We assume that portable mesh routers which are energy-constrained are used to configure WMN temporarily using drones in the disaster area. Therefore, each mesh router may act selfishly when forwarding packets to conserve its energy depending on its energy status.
In our proposed scheme, we detect selfish nodes among previously selected candidate nodes for content caching using the concept of energy increasing rate (EIR) measured from the energy profile of each mesh router. We adopt the EIR as a trust metric proposed in our previous work [17]. Let $\rho_k$ denote the carried traffic load at the instant time $t$ and $f_k(\cdot)$ denote the energy profile of the network equipment $k$. The EIR represents the additional energy required to deliver the unit traffic passing through a network equipment $k$, that is, $f_k(\rho_k)$ is the required energy to process $\rho_k$ at time $t$. Then, EIR can be defined using the slope of the energy profile at time $t$ as below.

$$e(k) = \frac{f_k(\rho_k + \Delta) - f_k(\rho_k)}{\Delta},$$

(2)

where $\Delta$ is the unit traffic (e.g. 1Mbps). Note that the EIR value can be calculated using the data sheet provided by network vendors or using the measured information such as traffic load and energy consumption provided by the measurement tools such as multi-router traffic grapher (MRTG) [18] and WireShark [19]. For instance, if a mesh router with low EIR is

<table>
<thead>
<tr>
<th>Energy profiles</th>
<th>EIR value $(\nu_2)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cubic model ($y = e^{x-0.5} - 0.6$)</td>
<td>0.1 - 0.5</td>
</tr>
<tr>
<td>Linear model ($y = x$)</td>
<td>0.5</td>
</tr>
<tr>
<td>Log model ($y = \log_{10}(x + 0.1) + 1$)</td>
<td>0.5 - 0.9</td>
</tr>
</tbody>
</table>

Table 1: The range of the EIR value ($\nu_2$)

![Simulation topology](image)

Fig. 3: Simulation topology
selected as a content caching node, it is less likely to be selfish because there was similar energy consumption before in spite of the increase of the traffic load by content caching. On the other hand, when a mesh router with rapidly increasing EIR is selected as a content caching node, it is more likely to be a selfish node to conserve its energy because of sudden increases in the energy consumption due to the increase of the traffic load by content caching. To assign a trust value to each mesh router, we consider three typical types of energy profiles among several well-known energy profiles of network equipment: cubic model, linear model, and log model. The range of the EIR value \( r_z \) is shown in Table 1. The number in 0.1 ~ 0.9 is assigned to \( r_z \) according to its energy profile model.

### 2.2.3 Trust Level Calculation

From those trust metrics which take into account both social and physical side, we finally assign a trust level of each mesh router, \( v_T \), according to the following formula:

\[
v_T = \alpha v_{AC} + (1 - \alpha) v_{EIR},
\]

where \( 0 \leq \alpha \leq 1 \) which is the trust level weighting factor.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation time</td>
<td>150 sec</td>
</tr>
<tr>
<td>Number of nodes</td>
<td>16</td>
</tr>
<tr>
<td>WMN routing protocol</td>
<td>HWMP proactive mode</td>
</tr>
<tr>
<td>Number of interfaces of each node</td>
<td>4</td>
</tr>
<tr>
<td>Link data rate</td>
<td>6 Mbps</td>
</tr>
<tr>
<td>Packet size</td>
<td>1024 Bytes</td>
</tr>
<tr>
<td>Trust level weighting factor ( \alpha )</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### Table 2: The traffic types in simulation

<table>
<thead>
<tr>
<th>Traffic type</th>
<th>Duration(sec)</th>
<th># of flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Background</td>
<td>UDP</td>
<td>Uniform(100)</td>
</tr>
<tr>
<td>Video contents</td>
<td>UDP</td>
<td>Exp(20)</td>
</tr>
</tbody>
</table>

### 6. Performance Evaluation

#### 3.1 Simulation Environment

In this section, we show the simulation results obtained by our proposed content placement scheme in WMN using the NS-3 network simulator [20]. We evaluate the normalized
throughput which is the ratio of the number of received packets over that of transmitted packets and the average end-to-end delay of each content flow according to whether content caching nodes exist or not.

Fig. 3 shows the simulation topology which consists of 15 general mesh routers and one mesh gateway. These routers composed in a 4 by 4 grid network to cover all over the disaster area are spaced 170 meters apart from each neighbor mesh router, and a mesh gateway which locates at the edge of the WMN topology is connected to the wired Internet gateway. Also, the SNS server is connected to the wired Internet gateway. Users are randomly distributed on the mesh nodes and they get the URL or video contents from the SNS server or a content caching node which locates at the mesh router determined by our proposed trust level. Each mesh node has four 802.11a interfaces with the 6 Mbps data rate. Though the channel allocation is an important issue in WMN, it is not the scope of this paper. We use static channel allocation using non-overlapping 12 channels.

We generate two types of traffic as in Table 2 based on traffic prediction in the Cisco white paper [21] which says that the video content traffic will reach 80% of all traffic by 2019. So, the percentage of content traffic in our simulation is 80% of overall network traffic volume. During the total simulation time (150 seconds), the background traffic is generated from the mesh gateway to each mesh router and the video content traffic is randomly generated having exponential distribution with average 20 seconds. Other simulation parameters are given in Table 3.

Fig. 4: The social network topology from the arbitrary Facebook network
To analyze logical network characteristics, we perform the social network analysis for an arbitrary network obtained from Facebook in [22] using SoNetV [23] which is one of top-10 social analysis tools. Fig. 4 shows the social network topology for the arbitrary Facebook network, which consists of 347 nodes and 5038 links, by the circle model according to the betweenness centrality of each node. In particular, the size of each circle indicates the value of the betweenness centrality of each node. The betweenness centrality values of all mesh routers in our scenario are given in Fig. 5.

We set the mesh router with index 3 as a mesh gateway which locates at the edge of the network, and choose the content caching nodes with the highest trust level. Because the network status and performance are unstable in the disaster area, we take into account up to two content caching nodes, which each content caching node has the same contents, for preparing the loss of content caching node. And, each mesh router randomly has one of three energy profile models in Table 1. The value of $V_E$ is determined by the EIR value of each mesh router at the given traffic load.

### 3.2 Performance Evaluation

Fig. 6 shows the normalized throughput of the proposed HTCP scheme under background
Fig. 6: Normalized throughput according to the content transmission rate; Background traffic: 300 kbps

traffic of 300 kbps. We compare to the no content placement scheme (No_CP) and the content placement scheme with only considering $V_{BC}$ (CP with $V_{BC}$) to show the performance when considering the characteristics of the physical network.

First, the normalized throughput of these schemes decreases as the transmission rate increases, especially in case of No_CP scheme, it decreases fast. Because users only receive the content traffic through the mesh gateway from the SNS server, the packet loss is caused by exceeding the wireless link capacity of the mesh gateway.

The yellow line indicates the normalized throughput when the mesh router which has the highest trust level is selected as a content caching node. Also, the red line indicates the normalized throughput with two content caching nodes. In CP with $V_{BC}$, the mesh router with index 11 which has the highest betweenness centrality among all of the nodes is selected as the content caching node as expected.

From the results, CP with $V_{BC}$ has better throughput performance than the No_CP scheme due to the additional traffic dissemination by the content caching mesh router with index 11. Also, we observe that the proposed HTCP schemes show better throughput performance than CP with $V_{BC}$. Because the CP with $V_{BC}$ does not take into account the physical state of the mesh router, the content caching node acts selfishly by dropping the content requests from other mesh routers according to its current EIR value. The HTCP with two caching nodes has better throughput performance than the HTCP with one caching node in the high traffic load. By choosing the two content caching nodes with high trust level, we can ensure much higher network bandwidth through the content traffic distribution. Our proposed HTCP scheme with two caching nodes shows the throughput improvement as traffic load increases, especially achieves 35% better normalized throughput performance than the No_CP scheme. Therefore, it is important to use a trust level which considers both the betweenness centrality and the
EIR value simultaneously in the content caching node selection.

Fig. 7 shows the average end-to-end delay of each content flow of the proposed HTCP scheme under background traffic of 300 kbps. The average end-to-end delay of four schemes increases as the transmission rate increases. No_CP has much higher average end-to-end delay than other schemes due to hop-by-hop transmission from source to the mesh gateway which is the typical characteristic of WMN. On the other hand, by taking into account the high influential content caching node as the broker in the social network relationship, the CP with $V_{BC}$ and the proposed HTCP schemes have better delay performance by reducing the physical distance between the SNS server and users. In addition, since the proposed HTCP schemes select the caching nodes by considering the selfish behavior, the average end-to-end delay performance is better than CP with $V_{BC}$ by decreasing retransmission times and increasing transmission chances from the content caching node. Especially, the HTCP with two caching nodes has better end-to-end delay performance than the HTCP with one caching node in the high traffic load. It ensures much faster and more reliable content distribution in the disaster area using two caching nodes with high trust level.

To summarize, as our proposed HTCP scheme considers the EIR value of the physical network and the betweenness centrality of the logical network, it shows the best throughput and delay performance compared to No_CP and CP with $V_{BC}$ in WMN since the proposed HTCP scheme selects the content caching node which is able to rapidly and efficiently disseminate the information.

7. Conclusions
In this paper, we proposed the Hybrid Trust-aware Content Placement (HTCP) scheme for wireless mesh network in the disaster area. The HTCP scheme takes into account physical
network and logical network characteristics simultaneously. To define a trust level, we suggested the energy increasing rate as a physical network metric and the betweenness centrality as a logical network metric. From the simulation results, the suggested scheme gives a significant positive effect on the overall throughput and average end-to-end delay of each content flow. Using the HTCP scheme, we achieve fast and efficient dissemination of the information in the disaster area. As a future work, we have a plan to consider additional factors as a trust metric for other service environments.

8. Acknowledgement
This work was supported by the ICT R&D program of MSIP/IITP. [R0190-15-2027, Development of TII(Trusted Information Infrastructure) S/W Framework for Realizing Trustworthy IoT Eco-system].

9. References


ICEAI-1183
Nonlinear Saturable Absorbers based on Graphene Directly Synthesized onto Device Surface with Telecom Laser

Pulak C. Debnath\textsuperscript{a,b}, Jaehyun Park\textsuperscript{a}, Yong-Won Song\textsuperscript{a,b}

\textsuperscript{a}Center for Opto-Electronic Materials and Devices, Korea Institute of Science and Technology, Seoul 136-791, South Korea

\textsuperscript{b}Nanomaterials Science and Engineering, Korea University of Science and Technology, Daejeon 305-350, South Korea

E-mail address: ysong@kist.re.kr

1. Background/ Objectives and Goals

Till date, most well-known and reported methods for incorporating pre-synthesized graphene into a fiber ring cavity for mode-locking purposes are to insert graphene layer between two optical fiber end facets, or attach it to either the flattened side of a D-shaped fiber or around the waist of a tapered fiber. However, these methods have the drawbacks of transferring graphene films to the desired surface; more notably, the transfer processes have the issue of potentially incorporating unwanted impurities to graphene films, which result in damaged graphene layers and declined performance as saturable absorber (SA). To solve these issues, the deleterious transfer process should be avoided and an in situ synthesis of graphene directly onto the fiber components should be considered.

2. Methods

Here we report a room temperature in situ synthesis of multilayered graphene directly onto a single-mode fiber (SMF) without external C sources by irradiating a Ni catalyst with a continuous wave (CW) laser operating in the telecommunication band (C-band).

Polycrystalline Ni deposited on optical fiber end facet offers advantages of both the catalytic activity and the C source for interfacial formation of graphene. An amplified, C-band, CW laser is coupled into the SMF end opposite the Ni layer, which acts as a heating source for graphene growth. The incident laser increases the temperature at the Ni/SMF interface, and the nearby C atoms in the Ni begin to diffuse through the Ni and precipitate towards the Ni/SMF interface to form graphene. After the irradiation step, the Ni layer is etched away by placing the tip of the ferrule in a solution of 0.2 M Iron (III) Chloride (FeCl\textsubscript{3}) for 30 minutes, and we are left with graphene formed directly on the SMF end facet.

3. Expected Results/ Conclusion/ Contribution
The formation and the quality of the resulting multilayered graphene are confirmed by precision analysis tools. Raman spectra taken from different spots on the sample fiber end confirms the formation of good quality graphene without critical defects (D peak at 1350 cm$^{-1}$ is negligible, Significant G and 2D band at 1594 cm$^{-1}$ and 2680 cm$^{-1}$ respectively). The X-ray photoelectron spectroscopy (XPS) analysis on the grown graphene shows that 75.8% of the C atoms are with sp$^2$ hybridization, which further supports the formation of graphene. The synthesized graphene shows nonlinear optical absorption property with the modulation depth of 7%, guaranteeing passive mode-locking of fiber laser operating in femtosecond scale. This sample is used as a mode-locker in the fiber laser ring cavity to generate ultrashort pulsed laser with average output power of 2.46 mW (using 10/90 coupler). The optical spectrum of the mode-locked pulses is centered at 1571.96 nm with a full width half maximum (FWHM) of 0.75 nm. The pulse train has a repetition rate ($f_{rep}$) of 15.06 MHz, which matches with the cavity round trip time and verifies that the laser was mode-locked in fundamental mode operation. A fast photodiode has been used for optical-to-electrical conversion which shows the RF spectrum with peak-to-noise ratio of 51 dB ($\approx10^5$ contrast) for the fundamental peak centered at the cavity repetition rate, indicates the stability of our laser.

This synthesis technique also can be utilized to form graphene on the flat surface of D-shaped fiber and also many other surfaces, which can improve the current technology in the area of photonics, optical communications and optical computing.

Acknowledgment: This work was supported by the National Research Foundation (NRF), funded by the Ministry of Science, ICT and Future Planning, South Korea (Grant No. NRF-2015R1A2A2A04006979).

Keywords: Fibers laser, graphene, direct synthesis, optical nonlinearity, saturable absorber
ICEAI-1192
Design of Fractional Order Model Reference Adaptive Controller

Ozkan ATAN\textsuperscript{a,}\textsuperscript{*}, Mustafa TURK\textsuperscript{b}
\textsuperscript{a} Electric-Electronic Engineering, Yuzuncu Yil University, Turkey
E-mail address: oatan@gmail.com

\textsuperscript{b} Electric-Electronic Engineering, Firat University, Turkey
E-mail address: mturk@firat.edu.tr

Abstract
In this study, control systems are designed based on fractional order model reference control (FO-MRC). There are two different methods for FO-MRC which, FO adaptation method and fractional order (FO) modelling of MRC. FO model and plant system, and FO adaptation method are used. FO modelling and FO adaptation are caused some effects in the control system. This study is shown that the order is affected by control performance, which overshoot and steady state error.

Keywords: Fractional order systems, adaptive control, model reference control.

1. Introduction
The model reference control (MRC) is one of the adaptive control methods, first used in middle of 20th century. In the recent years, this control method has been applied many different fields, such as control of air vehicle systems, satellite systems and treatment of cancer, and the most of the researches obtained good results [1-4]. Aim of the adaptive MRC system, output of the plant is to track the output of the reference model. In adaptive MRC systems, controller parameters are changed by error between plant and model system, and the system is provided robust control against the change of plant parameters and the noise [5-9].

Researchers realized adaptive MRC method for fractional order systems. When control system is modelling with fractional order systems, increases controller performance [10-12]. There are two ways in MRC method; fractional order modelling of MRC and fractional order adaptation law [13-17]. In study of Vinagre, three topics in fractional order MRC are underlined. These are;

- Optimum design of fractional order MRC,
- Stability boundaries of adaptation gain and fractional order,
- Analysis of fractional order MRC in frequency domain.
In this paper, we study design controller for Fractional order systems using fractional order MRC method. The effect of fractional order on performance of fractional order MRC is researched and the optimum order has been determined. In the results, fractional order MRC is compared with classic MRC method.

This paper is organized as follows; calculus and analysis of fractional order are presented in Section II. Then classical and fractional order MRC methods are introduced in Section III. Simulation results are given in Section IV, and conclusion remarks are mentioned in Section V.

2. Fractional Order Calculus

Fractional order calculus is generalized version of integer order calculus. There are some solution methods for fractional calculus. One of them is Riemann-Liouville (RL) method [11-12]. Mathematical model of RL method is given by

$$\frac{d^\alpha}{dt^\alpha} f(t) = \lim_{h \to 0} \sum_{j=0}^{[t/h]} (-1)^j \binom{\alpha}{j} f(t-jh)$$  \quad (1)

The other method of fractional calculus is Grünvald-Letnikov (GL) method [11-12]. Mathematical model of GL method is given by;

$$\frac{d^n}{dt^n} f(t) = \frac{1}{\Gamma(n-\alpha)} \frac{d^n}{dt^n} \int_0^t (t-\tau)^{\alpha-n-1} f(\tau) d\tau$$ \quad (2)

In the equations, \( \alpha \) is the order of the system. RL method is discreet time solution and GL method is continuous time solution method. Another solution method of the fractional order systems is Laplace transform method. When initial condition is zero, the Laplace operator is;

$$L\left[ \frac{d^\alpha f(t)}{dt^\alpha} \right] = s^\alpha F(s)$$ \quad (3)

There are different methods for solution \( s^\alpha \); Carlson, Matsuda and Crone methods. Crone method is generally used in literature [10-12]. Mathematical model of the Crone method is
The method is transformed a transfer function that is infinity long, and poles-zeros of the transfer function are changed according to the order.

3. Model Reference Adaptive Control

3.1 Classic Model Reference Control (MRC)

In adaptive MRC method, parameters of the controller are changed according to error between the plant system and reference system. Blok model of adaptive MRC is shown in Figure 1.

Mathematical model of MRC is given by:

\[
\frac{dy}{dt} - ay - bu = 0 \\
\frac{dy_m}{dt} - a_m y_m - b_m u_c = 0
\]  

![Figure 1. Adaptive Model reference control.](image)

Gain of the controller, \(\Theta_1\) and \(\Theta_2\) are changed according to the error. Mathematical model of the controller input is:

\[
u = \theta_1 y + \theta_2 u_c
\]
3.2 Fractional order MRC

There are two different methods for fractional order MRC method. They are:

- Fractional order model method,
- Fractional order adaptation method [17]

Mathematical model of fractional order model method given by:

\[
\frac{d^\alpha y}{dt^\alpha} - cy - bu = 0
\]

\[
\frac{d^\alpha y_m}{dt^\alpha} - ay_m - bu = 0
\]

The controller input is:

\[
u = \theta_2 y + \theta_2 u_c
\]

Error and change of the error are:

\[
e = y_m - y
\]

\[
\frac{de}{dt} = \frac{\dot{y}_m}{y} - \frac{\ddot{y}}{\ddot{y}} = \frac{d^{1-\alpha}}{dt^{1-\alpha}} \left[ \frac{d^\alpha y_m}{dt^\alpha} - \frac{d^\alpha y}{dt^\alpha} \right]
\]

Rewrite of the Eq. (9) and Eq. (10);

\[
\frac{de}{dt} = \frac{d^{1-\alpha}}{dt^{1-\alpha}} \left[ a_m y_m + b_m u_c - ay - bu \right]
\]

\[
= \frac{d^{1-\alpha}}{dt^{1-\alpha}} \left[ a_m y_m + b_m u_c - ay - b\theta_2 y + b\theta_2 u_c + a_m y - a_m y \right]
\]

\[
\frac{de}{dt} = \frac{d^{1-\alpha}}{dt^{1-\alpha}} \left[ a_m (y_m - y) + (b_m + b\theta_2) u_c + (a_m - a - b\theta_1) y \right]
\]

\[
= \frac{d^{1-\alpha}}{dt^{1-\alpha}} \left[ a_m e + \Delta_1 u_c + \Delta_2 y \right]
\]
Adaptation gains of fractional order MRC

\[ \Delta_1 = 0; \quad \theta_1 = \frac{a-a_m}{b} \]

\[ \Delta_2 = 0; \quad \theta_2 = \frac{b_m}{b} \]  \hspace{1cm} (12)

When MIT adaptation model is generalized for fractional order system, adaptation gains and adaptation orders are;

\[ \frac{d^\theta \theta_1}{dt^\theta} = -\gamma e y \]

\[ \frac{d^\theta \theta_2}{dt^\theta} = -\gamma e u \]  \hspace{1cm} (13)

Lyapunov stability of the system;

\[ V = \frac{1}{2} e^2 \geq 0 \]

\[ \dot{V} = ee \leq 0 \]  \hspace{1cm} (14)

Condition for inequality;

\[ V = (y - y_m) \frac{d^{\alpha-\alpha}}{dt^{\alpha-\alpha}} [a_m e] = e \frac{d^{\alpha-\alpha}}{dt^{\alpha-\alpha}} (a_m e) \]  \hspace{1cm} (15)

Theorem 1: In (16) and (17), stability of FO systems can be studied by using the condition;

\[
\begin{pmatrix}
D^\theta e_1 \\
D^\theta e_2 \\
D^\theta e_3
\end{pmatrix} =
\begin{pmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{pmatrix}
\begin{pmatrix}
e_1 \\
e_2 \\
e_3
\end{pmatrix}
\]

\[ T =
\begin{pmatrix}
a_{11} & a_{12} & a_{13} \\
a_{21} & a_{22} & a_{23} \\
a_{31} & a_{32} & a_{33}
\end{pmatrix}
\]

\[ \lambda = \text{eig}(T) \]

\[ |\text{arg}(\lambda)| \geq \alpha \frac{\pi}{2} \]  \hspace{1cm} (17)

According to the Theorem 1, condition of the stability:

\[ a_m < 0 \text{ ve } 0 < \alpha < 1 \]

4. Simulation Results
In the chapter, impact of change of the order on error between the model and plant system is observed. The parameters of the system and the model in Figure 1 are given by

\[
\begin{align*}
a_m &= -4, \quad b_m = 4; \\
a &= -2, \quad b = 2, \quad \alpha = 0.1; \\
0 &< \beta \leq 1 \quad 1 < \gamma < 5
\end{align*}
\] (18)

According to the parameters, change of the order and error are shown as Figure 2.

![Figure 2: Change of sum square of error according to adaptation orders.](image)

For different values of \( \alpha \), the error is decrease between \( \alpha = 0.1 \) and 0.66. Then, the error is decrease between \( \alpha = 0.66 \) and 0.9, it is same inverted bell curve. Value of the error becomes minimal when \( \alpha = 0.665 \).

When step input is applied to the system, changed of output of the model and plant is shown as Figure 3. It is seen that the error changed according to the order. The overshoot is increased, while the order is approached to 1, and steady-state error is not equal to zero while the order has a lower value than 1.

It is shown as Figure 4 that performance of the control system is not affected, while parameters of the plant system are changed.

The system parameters are given as below.

\[
\begin{align*}
a_m &= -4, \quad b_m = 4; \\
a &= -7, \quad b = 7, \quad \alpha = 0.1;
\end{align*}
\]
5. Conclusions

In this paper, performance of the MRC system which a different the noninteger adaptation order, has been presented. The overshoot is increased but steady-state error is converges to zero, while the order is approached to 1. Steady-state error is not equal to zero but the overshoot is decreased while the order has a lower value than 1. It is shown that the system performance isn’t negatively affected from change of parameters of fractional order plant system. Fractional order MRC System performance can be increased by the variable adaptation order.

6. References
[12] Zhang B T and Pi Y 2012 IET Control Theory A 6 829
Grid Tied Fuel Cell System Using Single Phase PLL Based SOGI with PI and PR Current Controllers

M. Emin Meral, Doğan Çelik
Department of Electrical and Electronics Engineering, Yuzuncu Yil University, Van, Turkey
Email address: aemeralm@yahoo.com, bdogancelik@yyu.edu.tr

Abstract
With the Declining reserves and polluting nature by fossil energy sources, the use of renewable energy sources (RES) have been increased. RES like the solar and wind, can't produce energy all the time due to depending air condition. But Fuel Cells (FCs) can be stored until it's needed. Power electronics plays an important role in converting the input power which is suitable delivered to the utility grid. Voltage source inverter (VSI) is the most widely used solution for connecting a low power RES to the grid. This paper present grid tied fuel cell system using single phase PLL based SOGI with PI and PR current/power controllers. The SOGI algorithm is used, in interaction with a PLL for grid voltage and frequency synchronization. The electrical characteristic of SOFC is analysed under constant and variable DC loads. Controllers of the PI and PR are discussed in order to obtain the control of inverter along with the variation of active power and grid voltage drop. The system is modelled and simulated using PSCAD/EMTDC software package. Simulation results show the effectiveness of both the controllers and PLL technique based SOGI for the synchronising of the SOFC systems with the single phase grid successfully.

Keywords: SOGI, Single Phase PLL, PR Current Controller, PI Current Controller, SOFC

1. Introduction
In the last years, an interest toward Fuel Cell (FC) studies has grown, as FCs are a clean and efficient source of electricity, and have a wide range of transportation and stationary applications. FCs have a wide variety of potential applications including micropower, auxiliary power, transportaiton, stationary power buildings and cogeneration applications. FCs are capable of operating at efficiencies greater than traditional energy production methods.

Moreover, the scalability of fuel cells has allowed for applications in almost every field. FC systems can be easily placed at any side in a power system for grid reinforcement. Therefore, proper controllers need to be designed for a fuel cell system to make its performance characteristics as desired (Salam, et. al.,2008). There are different types of fuel cells which are classified according to their electrolyte material and operating temperature such as Proton Exchange Membrane (PEMFC), Alkaline, Phosphoric Acid, Solid Oxide (SOFC), Molten
Carbonate and Direct Methanol Fuel Cells (Shouman, et. al., 2012). Solid oxide fuel cell receives more and more attentions because of its high efficiency, higher power density, operating at high temperature and almost zero impact to environment as a tool for conversing energy into electricity. However, its expensive fabrication cost significantly limits the development of SOFCs for practical applications.

Generally, a power electronic converter is required to transfer the electricity generated from these energy sources to the utility grid. A single-phase VSI is the most suitable solution for connecting a low power RES to the single phase grid. To regulate the power exchange with the grid, and at the same time, reduce harmonic components in the alternating current (AC) side current, various control strategies have been proposed, such as proportional integrator (PI) controller and proportional resonant (PR) controller (Monfared, et. al., 2012). The control system for the inverter consists of the synchronization controller which is a phase locked loop (PLL) that constantly tracks the phase of the grid voltage (Assefa, et. al., 2009). The PLL is used to detect the phase of the grid voltage and for that purpose an orthogonal voltage system needs to be generated. In single-phase systems there is less information than in three-phase systems regarding the grid condition, so more advanced methods should be considered in order to create an orthogonal voltage system (Ciobotaru, et. al., 2006).

A second-order generalized integrator (SOGI) is used for generation of an artificial orthogonal voltage as input to the PLL. SOGI algorithm is normally used, in interaction with a PLL for grid voltage and frequency synchronization. It is easy to implement and it can filter the input signal without delay due to its natural resonance at the fundamental frequency .The SOGI algorithm is essentially an effective way to provide an orthogonal signal system that it is insensitive to the input signal noise (Matas, et. al., 2010).

The current regulation is an important issue for the inverter control. In the literature, PI controller, which is normally used in VSI, cannot be a satisfactory controller for an AC system because of the steady-state error and the poor disturbance rejection (Vu, et. al, 2010)

PR current controllers are implemented in many power electronics applications of grid connected inverters. The reasons for using these controllers are provided zero steady state error at the resonant frequency and it has low order current harmonic content (Ortiz Martinz, et. al., 2014).

There are less information and studies on SOFC system synchronizing with the single phase grid than synchronizing with the three phase grid in the literature. This paper presents a single phase SOFC system (consist of Fuel cell, boost converter and inverter) using SOGI based PLL with PR and PI current controllers for the synchronizing with the single phase grid. The major
contribution of this paper is comparison of total harmonic distortion (THD) and response speed of PR and PI current controllers. The system is modeled and simulated by using PSCAD/EMTDC software package.

2. Fuel Cell System Configuration

The implemented Fuel Cell system in PSCAD/EMTDC is shown in Fig. 1 where a single phase SOFC is connected to DC/DC boost converter followed by an inverter, LC filter and utility grid. The output voltage from the inverter contains high order harmonics which must be eliminated and thus, a low LC filter is used to reduce the harmonic contents in the phase current and the output voltage. The technical details of each part of the system are given in the following subsections.

2.1 SOFC Design

The stack voltage and the reference power are determined the reference current which is determined for the fuel cell stack current. The fuel flow is proportional to the stack current. The dynamic model of the SOFC stack is presented based its electrochemical and thermodynamic characteristics and emphasis on the fuel cell terminal electrical characteristics (Akkinapragada, 2007, Fedakar, 2012). The partial pressure of hydrogen, oxygen and water are determined using the flow rates of hydrogen and oxygen. The stack current and pressure of gases affect the stack voltage (Fedakar, et. al., 2103) A simulation model is developed for the SOFC in PSCAD/EMTDC based on the dynamic SOFC stack. The output voltage of the stack is given
by the Nernst equation. The ohmic loss of the stack results from the resistance of the electrodes and to the resistance of the flow of oxygen ions through the electrolyte.

$E_0$ is Standard reversible cell potential, $r$ is internal resistance of stack, $I_{fc}$ is stack current, $N$ is number of cells in stack, $R$ is universal gas constant, $T$ is stack temperature and $F$ is Faraday’s constant, considering ohmic losses of the stack, the expression of total fuel cell stack voltage can be written as

$$V_{fc} = N_0 \left( E_0 + \frac{RT}{2F} \left( \ln \frac{P_{H_2}P_{O_2}^{0.5}}{P_{H_2O}} \right) \right) - rI_{fc} \tag{1}$$

$P_{H_2}$ is partial pressure of hydrogen;

$$P_{H_2} = \left( \frac{1}{KH_2} \right) \left( qH_2 - 2KrI \right) \tag{2}$$

$P_{O_2}$ is partial pressure of oxygen;

$$P_{O_2} = \left( \frac{1}{KO_2} \right) \left( qO_2 - 2KrI \right) \tag{3}$$

$P_{H_2O}$ is partial pressure of water;

$$P_{H_2O} = \left( \frac{1}{KH_2O} \right) \left( 2KrI \right) \tag{4}$$

$I_{ref}$ is the reference current ,

$$I_{ref} = \frac{P_{ref}}{V_{fc}} \tag{5}$$

$$I_{fc} = \frac{I_{ref}}{1 + \tau_e S} \tag{6}$$

$qH_2^r = 2KrI \tag{7}$

$qO_2^r = \frac{qH_2}{rH_2O} \tag{8}$

The power output of fuel cell system is the product of stack current and voltage.

$$P_{fc} = N_0V_{fc}I_{fc} \tag{9}$$
2.2 Boost Converter Design

Fuel cells operate at low DC voltages and so need to be step up with the help of a DC-DC converter (Akkinapragada, 2007). DC-DC Boost Converter is used to step-up and to regulate the DC voltage (Salam, et. al., 2009). And also capacitor used for smoothing the output voltage. The pulse width modulation (PWM) signal with PI Controller provides control and regulation of output dc voltage (Ngema, et. al. 2010). DC-DC converter is light weight efficient power conversion which are widely in many application. Although different topologies converter, the basic converter used to step up input voltage is Boost converter (Ciobotaru, et. al., 2005).

The switching signal to the IGBT is given by the closed loop feedback control system in Fig. 2. The error signal is fed into the compensator to obtain the control voltage. The gate signal is produced by the PI controller. The converter’s output and the reference voltage are subtracted and the reference current (Idc_ref) is obtained. Then Idc_ref and fuel cell current are subtracted and the error signal signal is fed into the comparator to compare with triangular wave to achieve the required PWM gate signal.

![Fig. 2 Boost Converter Feedback Controller System](image)

2.3 Inverter Design

The model of the VSI used in this work based on the IGBT single-phase inverter model is developed. The inverter has two bridge arms, composed each one by two IGBT (with parallel) diodes as power switches (Garcia, et. al., 2014). The SOFC-DC converter system is connected to the utility grid through a DC-AC inverter. The transistor switching signals for the inverter are obtained from Current/Power control system.

The single-phase inverter is controlled by using a sinusoidal-pulse width modulation (SPWM) technique, its feedback is controlled by active and reactive power control with PR or PI current controllers.
3. Proposed Control Scheme

3.1 Single Phase (PLL) Based Second Order Generalized Integrator (SOGI)

Different methodologies (Assefa, 2009) for creating an orthogonal signal has been suggested for single phase PLLs, a second order generalized integrator (SOGI) is used in this paper. SOGI algorithm is normally used, in interaction with a PLL. The SOGI algorithm is essentially an effective way to provide an orthogonal signal system that it is insensitive to the input signal noise. The SOGI scheme is based on a frequency-adjustable resonator, which can be implemented by two cascaded integrators working in a closed loop in Fig. 3 (Matas, et. al., 2010).

The closed-loop transfer functions are given as:

\[
H_\alpha(s) = \frac{K_{\text{sogi}}\omega_0 s}{s^2 + K_{\text{sogi}}\omega_0 s + \omega_0^2}
\]  

\[
H_\beta(s) = \frac{K_{\text{sogi}}\omega_0^2}{s^2 + K_{\text{sogi}}\omega_0 s + \omega_0^2}
\]

Where \(\omega_0\) is the nature frequency of signal and generates two orthogonal sine waves as outputs \(V_d\) and \(V_q\). The output \(V_d\) is in phase with the fundamental component of the input signal \(V_p\). The gain affects the bandwidth of SOGI. If \(K_{\text{sogi}}\) decreases, the filter becomes narrower resulting in a heavy filtering, but at the same time the dynamic response of the system becomes slower. The tuning of this structure is frequency dependent and can face problems when grid frequency has fluctuations. Therefore, the resonant frequency of SOGI is adjusted by the output frequency of PLL structure (Vishnu, 2013).
The control strategy can be applied in single-phase PLL by creating SOGI. Proposed a single phase PLL algorithm which is based on the inverse park transformation in equation 12 (Assefa, 2009).

\[
\begin{bmatrix}
V_d \\
V_q
\end{bmatrix} = 
\begin{bmatrix}
\cos(\theta_{pI}) & \sin(\theta_{pI}) \\
-sin(\theta_{pI}) & \cos(\theta_{pI})
\end{bmatrix} \begin{bmatrix}
V_a \\
V_b
\end{bmatrix}
\]

(12)

3.2 PI Current Controller
PI controller is one of the most widely use current tracking controller for grid tied inverter. The PI controller is expressed as follows:

\[ G(s) = K_p + \frac{K_i}{s} \]  

(13)

The value of the controller gains are not changing when the controller is transformed in difference reference frame, same value of \( K_p \) and \( K_i \) can be used for the PI controllers.

3.3 The Proportional Resonant (PR) Current Controller
In spite of the fact that its popularity, a PI controller is not able to track a sinusoidal reference without the steady-state error (magnitude and phase). PI controller such as lack of tracking a sinusoidal reference with zero steady-state error and poor disturbance rejection capability (Hojabri, et. al., 2012). To overcome the mentioned problems of conventional PI controllers in the stationary reference frame, PR current controller is proposed. The PR controller provides a high gain and zero steady-state error. Besides its simplicity, the system dynamics is almost not affected by the harmonic compensation terms. However, the PR controller is difficult to implement in reality. It has two problems. Firstly, the infinite gain introduced by a PR controller leads to an infinite quality factor which cannot be achieved in an analog or a digital system processor. Secondly, the gain of the PR controller is much decreased at other frequencies and it is not adequate to eliminate harmonic influence caused by grid voltage harmonics (Sultani, 2013, Monfared, 2012).

Fig. 4 shows that \( \omega_0 \) is grid fundamental angular frequency and \( k_i \) is a constant which is carefully selected to shift the controller's magnitude response vertically (Hojabri, et. al., 2012).

\[ G(s) = k_p + \frac{k_i \omega_c s}{s^2 + 2\omega_c s + \omega_o^2} \]  

(14)

And \( k_p \) and \( k_i \) are the proportional and integral gains of PR controller respectively, and \( \omega_c \) is cut-off angular frequency. The transfer function shows a non ideal PR controller which has
lower gain and wider bandwidth than ideal PR controller at the resonant frequency (Hojabri, et. al., 2012).

PR gain is finite, but it is relatively high for enforcing a small steady-state error. The controller’s bandwidth can be widened by setting \( \omega_c \) suitably, which helps to reduce sensitivity towards slight frequency variations (Komurcugil, 2014).

### 4. Simulation Results

Variable DC load tied to the fuel cell is changed from 1 ohm to 2.5 ohm. Fig. 5 shows the fuel cell stack current under variable DC loads. The fuel cell stacks current, voltage and power increase and decrease with the DC load change. The PR controller has similar dynamic behaviour to the PI controller due to a step change active power depending reference power in Fig.6. PR and PI controllers, they can control the system with the same dynamic performance when active power change depending reference power but PR has better performances in the grid voltage drop. When grid voltage decrease between 2.46s-2.7s, the response of PR controller is better than the PI controller. Fig.7 shows THD is found to be 1.5% in case of PR controller and 4.5% in case of PI controller.
5. Conclusion

The SOFC system, boost converter and a closed loop feedback control structure, grid tied single phase VSI and single phase PLL based SOGI with PI and PR control structure are modelled and simulated using PSCAD/EMTDC. Single phase system is needed to generate a pair of orthogonal voltages. Orthogonal signal is generated by SOGI. Single phase PLL technique based SOGI can be used for the synchronising of the SOFC systems with the single phase grid. The performances of the PI and PR current controller are analysed. The advantage of PR controller reduces THD and achieves a high quality current.
6. References


Highly Sensitive Airgap Fiber Fabry-Pérot Interferometer Based on Multilayer Dielectric Thin Film Coated on the Fiber Endfaces

Wei-Chieh Lee, Nai-Jie Huang, Cyun-Lun Zeng, Fan-Bean Wu, Cheng-Ling Lee*  
\(^a\) Department of Electro-Optical Engineering, National United University, Taiwan.  
\(^b\) Department of Material and Science Engineering, National United University, Taiwan.  
*E-mail address: cherry@nuu.edu.tw

Abstract

This work presents a highly sensitive fiber sensor based on a microgap of air fiber Fabry–Pérot interferometer (AFFPI). The sensor is fabricated by two endface of single mode fibers that are coated on multilayer dielectric thin film. The high reflectors of the two fiber endfaces with the multilayer dielectric thin film can form a good finesse Fiber Fabry–Pérot cavity. Then the two reflectors are aligned face to face with a tiny airgap using a thermal epoxy for fixing the alignment of two fibers. Experimental results show that the present device is highly temperature sensitive with the thermal sensitivity of 13.9 nm/°C.

Keywords: Fiber Fabry–Pérot interferometer (FFPI), Temperature sensor, Microgap of air, fiber sensor, fiber-optics component.

1. Introduction

Owing to fiber interferometer sensors which have the advantages of all-fiber configuration, high sensitivity, lightweight, low-loss, anti-electromagnetic interference and long-distance transmission. They have been widely used in many fields of technological innovations and applications. Among these fiber sensors, the fiber Fabry–Pérot interferometers (FFPIs) have been comprehensively used in sensing various parameters, such as humidity [3], temperature [3–6], refractive index [7], flow [8], and strain [9]. The FFPIs are usually based on the structure of air-gap Fabry–Pérot cavity but there are liquid cavity based FFPIs have been reported recently [10–11]. Several spherical air bubbles have been formed by fusion splicing with single-mode fibers (SMF). The air gap inside the FFPIs was formed by hydrofluoric acid etching fiber endface and then by fusion process [12–13]. Besides, a new technique involves use of fs-laser micromachining to carve the fiber to form the air-gap. This method is advanced, convenient and requires no alignment, but it does require an expansive laser [14–15]. In this study, we present a highly temperature sensitive air-gap FFPI that is fabricated by two aligned fibers that were clamped by two thin cover glasses with thickness of 0.14mm. After that, the sandwiched fibers were fixed by a thermal-sensitive epoxy on a set of general glass slides. The
proposed airgap fiber Fabry–Pérot interferometer (AFFPI) was investigated the thermal characteristics to achieve the high temperature sensitivity.

2. Methods
In the fabrication of the AFFPI, the endfaces of two single mode fibers (SMFs) were coated on multilayer dielectric thin film to make high reflection mirrors. The two coated single mode fiber were firstly fixed on the optical stages and separated by a small airgap with a certain length of d. The endfaces of the SMFs were monitored by a CCD microscope during the fabrication processes. And then, the SMFs on the stages are aligned precisely by adjusting the fiber holders under the monitored CCD microscope. Two holders fixed the endfaces of both fibers and are clamped tightly by the two cover glasses. In the meanwhile, epoxy is used to fix the two SMFs and two cover glasses for maintaining the air gap with a certain length of d, as displayed in the inset of Fig. 1. Figure 1 shows the schematic diagram of the proposed AFFPI.

![Schematic diagram of the proposed AFFPI](image)

The experimental setup for making the temperature measurement was shown in Fig. 2. The light from a broadband light source (BLS) propagated into the device, and the interference spectra were detected by an Optical spectrum analyzer (OSA). Experimental results show the air gap in the AFFPI makes the device more sensitive in measuring temperature (T) by monitoring the optical Fabry–Pérot interference peaks shift.
3. Experimental results and discussion

In the experiment, two endface of single mode fibers were firstly coated on multilayer dielectric thin film to fabricate high reflective mirrors for forming the Fabry–Pérot cavity. Figure 3(a) show the reflection spectra of the two coated SMFs. The reflection and transmission spectra of the sensor with airgap of 14μm are displayed in the Fig. 3(b).

To demonstrate the effective sensing performance of $T$ for the proposed AFFPI sensor, the sensor is placed on a TE cooler (resolution: $\pm 0.05^\circ$C) inside a closed space with the temperature $T$ ($^\circ$C) changed only from 20$^\circ$C to 21$^\circ$C. Spectral responses of the sensor are directly monitored by using the optical spectrum analyzer (OSA). The sensor has averagely thermal sensitivity about 13.9 nm/$^\circ$C for a cycle of thermal process, as presented in Figs. 4 and 5. In the Fig. 4, the coated fibers are pulled out by the thermal expansion of glass slides which causes a red-shift in the interference fringes due to the gap enlargement when the device is heated. The airgap would be reversed back to the original condition since the epoxy between the fiber and glass slides have elasticity within the small temperature variation of only 1$^\circ$C.
Figure 4 shows the detailed spectral responses of sensor with d~14μm under the heating and cooling processes, respectively. Figure 4 plots the linear fitted responses of sensor to the variation in $T$ of 1°C. Here, the parameter $S = 13.9$ nm/°C is the average sensitivity of the sensor for one cycle of measurement. The measured results reveal repeatability and good linearity performance for the heating and cooling processes.

Since the optical interference is mainly related to the airgap cavity, only the change in length of the airgap is considered herein. Thus, the variation of the cavity length after heating or cooling by temperature change ($\Delta T$) is shown below:

$$\Delta d = \alpha_{\text{glass}} \cdot (D+d) \cdot \Delta T - (\alpha_{\text{SMF}} \cdot D \cdot \Delta T + \alpha_{\text{epoxy}} \cdot L \cdot \Delta T)$$

(1)

Here, $d$ represents the original length of the airgap. $D$ is the length of SMF in the sensor structure. $L$ is the length of epoxy placed at the fiber, as displayed in the inset of Fig. 1. $\alpha_{\text{glass}}$ ($\sim 7.1 \times 10^{-6}$ °C$^{-1}$), $\alpha_{\text{SMF}}$ ($\sim 5.5 \times 10^{-7}$ °C$^{-1}$) and $\alpha_{\text{epoxy}}$ ($\sim 4.8 \times 10^{-6}$ °C$^{-1}$) are the TEC of glass slides, SMF and epoxy, respectively. Based on the Eq. (1), the $\Delta d$ is positive when in heating to result the red shit of the optical interference spectra. The interference wavelength shifts ($\Delta \lambda$) and the cavity variation of the air ($\Delta d$) at a specific wavelength ($\lambda$) satisfy the relation $\Delta \lambda/\lambda = \Delta d/d$. The thermal sensitivity can be defined as $S \equiv \Delta \lambda/\Delta T$ (nm/°C). Figure 5 shows the $S$ can be as high as
13.9nm/°C which is about 700 times than that of general fiber Bragg grating sensor (0.02nm/°C) to demonstrate the high sensitivity of the present device.

Fig. 4: Variations of transmission spectra of sensor at air gap. Inset (a) shows the variations of transmission spectra of sensor at air gap as T increases. Inset (b) shows the variations of transmission spectra of sensor at air gap as T decreases.

Fig. 5: Sensitivities of wavelength shift to the temperature variation of 1°C for the air gap.

4. Conclusion
This work has demonstrated a highly temperature sensitive and in-line AFFPI based on two SMFs alignment with sandwiched by two thin glasses. The microgap of the AFFPI is clamped by two cover glasses and fixed by packaged epoxy well to ensure the micro-gap of air and two fibers therein are permanent. Experimental results show that the highly thermal sensitivity of 13.9 nm/°C with linear spectral response can be achieved. Furthermore, the thermal sensitivity of the device can be controlled by changing the microgap between two SMFs. The developed AFFPI is flexible and cost effective that has a potential application for other fields.

5. References


ICEAI-1196
Measurement of Temperature Dependent Thermal Expansion Coefficient of Polymer in a Microcavity Hollow Core Fiber Fabry–Pérot Interferometer

Hsiu-Yu Fan, Shih-Hsiang Lu, Jheng-Hong Gu, Cheng-Ling Lee*
Department of Electro-Optical Engineering, National United University, Taiwan
E-mail address: cherry@nuu.edu.tw

Abstract
We develop an ultracompact fiber-optic sensor that can measure parameter of temperature dependent thermal expansion coefficient (TEC) of the polymer in a hollow core fiber (HCF) structure. It is fabricated by a single mode fiber (SMF) fused a tiny section of hollow core fiber (HCF) whose hollow core is filled with the test polymer to be as a microcavity fiber Fabry-Pérot interferometer (MFFPI). The proposed MFFPI can effectively and accurately determine the thermal expansion coefficient (TEC) of polymer NOA61 at different temperature (T). Experimental results show the values of TEC of the polymer NOA61 with the microcylindrical structure are strongly related with the surrounding temperature.

Keywords: Optical fiber sensor, Polymer, Fiber Fabry-Pérot interferometer, Thermal expansion coefficient (TEC), Hollow core fiber (HCF).

1. Introduction
Measurement of physical and optical parameters of a material used in the fields of optics and opto-electronics is very important. One of the important parameters, thermal expansion coefficient (TEC), has been investigated to evaluate the thermal characteristics of materials. The simplest expression of TEC is derivative of volume of the material (V) with respect to the temperature (T): dV/dT. However, very few optical fiber-based sensors have been proposed to measure the mentioned TEC of materials except the studies of [1-2]. Esposito et al. proposed a fiber Bragg grating (FBG) sensor to measure the TEC of polymers at cryogenic temperatures [1]. Other work has proposed a fiber-optic temperature sensor based on difference of thermal expansion coefficient between fused silica and metallic materials [2]. Therefore, the issue about the TEC in the materials is worthy to seriously investigate since the TEC parameter greatly influences the physical/optical characteristics of the used materials in many opto-electronics devices. Due to the TEC is an very important parameter in many fields of such material science and opto-electronics. In this study, for the first time we present an optical fiber sensor for measuring the TEC of a material, NOA61 polymer with microcylindrical structure. The studied device is based on a microcavity fiber Fabry-Pérot (F-P) interferometer (MFFPI), which is composed of a tiny section of hollow core fiber (HCF) whose hollow core is filled with the test polymer to achieve the F-P interference. The interferometer fabricated by fusion
splicing a small segment of HCF with inner diameter of D=30μm with a single-mode fiber (SMF). Thereafter, the HCF was filled with test material by capillary action through the feeding HCF by immersing the HCF end into NOA61 polymer. As well known in the published studies, various MFFPIs with smart, simple and hybrid structures have been reported for a different parametric sensing, such as of ambient temperature (T) [3-5], external refractive index (RI) [6], strain [7], and inclination [8]. Regardless of whether MFFPIs are fabricated by splicing various fibers, chemical etching, or femtosecond laser machining, the measurement of TEC parameter in the materials has never been proposed by using such the MFFPIs technology so far.

2. Experimental

To fabricate the proposed MPFFI, a sensor probe was formed by filling NOA61 monomer into the endface of HCF and the entire capillary process was monitored by using a microscope. The polymer NOA61 acts as a microcavity that generates low-finesse interference by reflecting from its interfaces and sensor endface. The NOA61 is a clear, colorless, liquid photopolymer that is cured by exposure to ultraviolet (UV) light. The curing process transforms the polymer NOA61 into a full solid and a well-bonded polymer structure. The adhesive force between the HCF and the NOA polymer is strong when the latter is fully cured [9]. In the experiment herein, the NOA61 capillary into the endface of the HCF becomes fully solid upon exposure to UV light with an intensity of around 5 mW/cm² for 30 sec at room temperature. However, in this state, the NOA61 does not reached its optimum adhesion to fiber, even with complete curing.

Therefore, the aging process was executed herein to form chemical bonds between the glass and the NOA61 polymer. Accordingly, the good adhesion, improved solvent resistance and an ability to withstand temperatures of up to 200ºC are achieved. These superior characteristics are very important in the fabrication of high quality opto-electronics devices and the achievement of long-term performance in a changing environment. Figure 1 shows the proposed fiber-optic sensing system. The measurement system comprises an optical spectrum analyzer, OSA; a broadband light source, BLS; index-matching liquid and the proposed MPFFI. A chamber with controlled temperature and humidity, THCC and a 2 × 2 optical fiber coupler are also used.

When the wideband light source propagates to the device, the two reflective beams from the (NOA61) polymer/silica interfaces of the microcavity HCF are combined in the SMF, producing interference patterns. Light that propagates into the HCF section with filled polymer that can cause F-P interference. The interference spectra of the MPFFI are analyzed using an optical spectrum analyzer (OSA). In the experiment, HCF was filled with the (NOA61) polymer with $n_D=1.56$. To ensure the polymer fully filled into the HCF, the evolution of (NOA61) polymer filling by capillary action was monitored under a microscope
and the spectra are measured by the OSA immediately. The microphotograph of the MFFPI sensor tip for measuring the TEC of (NOA61) polymer is shown in Fig. 2(a). Once HCF has been completely filled with polymer, the optical spectrum was measured as shown in Fig. 2(b). The duration of capillary action takes about 20 min in the case. The length of the polymer in HCF is estimated to be approximately 29.8 μm. At this moment of complete filling, two Fresnel beams from the (NOA61) polymer/silica interfaces of the (NOA61) polymer HCF can achieve the pure sinusoidal F-P interference that is displayed in the Fig. 2(b).

![Experimental setup for measuring TEC of material. Inset schematically depicts sensor head of MFFPI.](image)

3. Experimental Result and Discussion
In the TEC measurement, the temperature $T$ of the (NOA61) polymer-filled MFFPI was increased from 20°C to 50°C at a fixed humidity of 20% to evaluate the effect of $T$ on the interference spectra. When the proposed sensor was heated, the interference spectra shifted to
longer wavelengths (redshift) since the thermal effects on the NOA61 polymer cavity. Due to the thermal optics coefficient (TOC) is almost fixed during the T from 20°C to 50°C so that the thermal effect on the structure expansion of polymer cavity is only to be considered [9]. Figures 3(a)-3(b) display the wavelength shift of the interference peaks/dips as T is increased from 20°C to 50°C and decreased from 50°C to 20°C for (a) heating and (b) cooling processes, respectively. The insets of Figs. 3(a)-3(b) display the detailed wavelength shift (Δλ) due to the thermal effect of the TEC in the (NOA61) polymer. The wavelength is redshifted, that is the interference fringe shifts to long wavelength region while T increases from 20°C to 50°C. The measured sensitivity (Δλ/ΔT) shows the nonlinear response from T= 20°C ~50°C to demonstrate the temperature dependent TEC of the used polymer.

Based on the experimental results in Fig. 3, the TEC of the (NOA61) polymer can be obtained by analyzing the shifts in the interference dips/peaks. Fig. 4 schematically depicts the shift of the interference spectra of the polymer MFFPI as T increases. \( \lambda \) and \( \lambda' \) corresponds to the interference dips at T and \( T' = T + \Delta T \), respectively.
When $\alpha$ and $k$ denote the TEC and TOC of the filled NOA61, respectively. The $\alpha$ can be calculated using the following equation when the parameter $k$ of NOA61 has been already known as $-2.1 \times 10^{-4} \degree C^{-1}$ [9-11].

$$\alpha = \frac{\frac{\lambda'}{\beta} - k\Delta T - 1}{\Delta T + k\Delta T^2}$$

(1)

Figures 5(a)–5(b) show the obtained values of $\alpha$ of the polymer in HCF with microcylinrical structure that are related with (a) temperature ($T$) from 20°C to 50°C and (b) wavelength ($\lambda$) from 1500nm to 1600nm, respectively. Figure 5 indicates that the measured TECs are very strongly correlated with the operation $T$ but slightly dependent on the $\lambda$ of input light. The results for the (NOA61) polymer reveal that the TECs are almost linearly increased with increasing $T$ during 20°C to 50°C. The range of obtained TECs of the NOA61 polymer are $+2 \times 10^{-4} \degree C^{-1} \sim +5 \times 10^{-4} \degree C^{-1}$ during operation $T$ from 20°C to 50°C.

The results are different with those of the published studies [9,12] and official website of NOA company [9] with a almost fixed TEC of $+2.2 \times 10^{-4} \degree C^{-1}$ during $T=20°C \sim 50°C$. It can be explained as: the filled polymer is limited by the HCF whose TEC ($\sim 5 \times 10^{-4} \degree C^{-1}$) is ignorable.
to make the polymer only significantly expands to the air side as the T increases. The situation causes the TECs of the used polymer increased as the temperature rises.

4. Conclusion

An optical fiber sensor that is based on a microcavity fiber Fabry-Pérot interferometer (MPFFI) for measuring temperature-dependent TEC of the NOA61 polymer has been proposed and experimentally demonstrated. The proposed method using the MPFFI can effectively and accurately determine the TECs of polymer NOA61 at different temperature (T). Experimental results demonstrate that the measured TECs of the microcylindrical structure NOA61 polymer with the range of $+2 \times 10^{-4} \degree C^{-1}$ to $+5 \times 10^{-4} \degree C^{-1}$ are almost linearly dependent with T from 20°C to 50°C.

5. References


[9] https://www.norlandprod.com
Biological Sciences (3)

Thursday, May 12, 2016 08:45-10:15 Room 1007

Session Chair: Prof. Hiroshi Uechi

ICCBES-1073
A New Approach to Nonlinear Dynamical Systems with Conservation Law and Stability
Hiroshi Uechi | Osaka Gakuin University
Lisa Uechi | The University of Tokyo

ICCBES-1276
Homology Modeling and Docking Studies of Cloned Tyramine-β-Hydroxylase (TβH) from Drosophila Melanogaster
Md. Nazmul Hasan | Kyushu University
Abdullah Zubaer | University of Manitoba
Mohammad Jakir Hosen | Shahjalal University of Science and Technology
Hiroto Ohta | Kumamoto University
Jae Man Lee | Kyushu University
Takahiro Kusakabe | Kyushu University
Akinori Hirashima | Kyushu University

ICCBES-1317
Karyotype of Local and Imported Garlic (Allium sativum) in North Sumatera Indonesia
Tumiur Gultom | Medan State of University
Artha Manurung | Medan State of University
ICCBES-1327
Towards Understanding the Response Mechanisms to Cadmium Toxicity by Mangrove Fungus Trichoderma Atroviride
Mariam Taib | Universiti Malaysia Terengganu
Noor Afiza Badaluddin | Universiti Sultan Zainal Abidin
Syarul Nataqain Baharum | Universiti Kebangsaan Malaysia
Nur Faizah Mustapha Kamil | Universiti Malaysia Terengganu
Premasangery Kathivaloo | Universiti Malaysia Terengganu
Siti Athirah Mohamad Jamali | Universiti Malaysia Terengganu
Jamilah Mohd Salim Halim | Universiti Malaysia Terengganu
Aziz Ahmad | Universiti Malaysia Terengganu
Tengku Sifzizul Tengku Muhammad | Universiti Malaysia Terengganu
Noraznawati Ismail | Universiti Malaysia Terengganu

ICCBES-1364
Proteolysis Mediated ER Exit of Neuroligin 2 Regulates Synapse Development in Drosophila
Renjun Tu | Southeast University
Jinjun Qian | Southeast University
Mingkuan Sun | Southeast University
Wei Xie | Southeast University

ICCBES-1115
Simple and Rapid Determination of Norfloxacin Using Paper-Based Platforms in Food and Pharmaceutical Samples
Kwanchanok Wanawananon | Chiang Mai University
Kanyarak Prasertboonyai | Chiang Mai University
Narabhats Rannurags | Chiang Mai University
Saisunee Liawruangrath | Chiang Mai University
ICCBES-1073
A New Approach to Nonlinear Dynamical Systems with Conservation Law and Stability

Lisa Uechi\textsuperscript{a}, Hiroshi Uechi\textsuperscript{b}

\textsuperscript{a}Institute of Industrial Science, The University of Tokyo, Japan
E-mail address: luechi@telu.iis.u-tokyo.ac.jp

\textsuperscript{b}Department of Commerce, Osaka Gakuin University, Japan
E-mail address: uechi@ogu.ac.jp

1. Background
The Lotka-Volterra (LV) equations known as predator-prey equations are nonlinear differential equations frequently applied to biological, ecological phenomena to understand population growth, interactions of species in ecosystems, microbiology, pattern formations and interactions in morphogenesis and complex systems in nonlinear chemical reactions.

2. Methods
Nonlinear dynamical systems characterized by self-interactions, dissipative structure, nonlinear cooperative phenomena and our approach to nonlinear phenomena based on conservation laws are briefly reviewed. Natural phenomena are considered to be realizations of nonlinear dynamical interactions, playing essential roles not only in natural sciences but also in economy, ecology, and environmental sciences\cite{1,2}.

Nonlinear phenomena are difficult to handle because of their complex interactions and structures, self-organizations, spontaneous emergence of order, which may exhibit no simple laws or orders. However, complex systems constitute cells, organs, and living animals which totally make very stable systems. There may be some conservation laws corresponding to the stability observed in microbiological and ecological systems\cite{3}. This is a motive that we applied nonlinear analyses based on Noether's theorem in dynamics\cite{4,5}, and interesting results for complex phenomena are discussed.

However, as we explained, an ecological system is an example of the stable dynamical systems, from microbiological systems such as DNA and RNA, amino acids and proteins, cells and organs, to macroscopic systems as the 10-year cycle of Canadian lynx and snowshoe hair\cite{6}, wolves and caribous, marine coral reefs.

The stability suggests that some conservation laws and symmetries are inherent from complex microbiological systems to macroscopic ecological systems. Hence, conservation laws
corresponding to biological stability could be possible, which leads to a fundamental assumption for the model of our conserving binary-coupled form (BCF) based on Noether's theorem in dynamical systems[7,8].

3. Remarks

We examined characteristic properties of several ecological systems based on conserved nonlinear interactions which include generalized Lotka-Volterra type prey-predator, competitive interactions. The important property of our nonlinear model (BCF) with conservation law is that the binary-coupled system can have a persistent stability and recovering strength to external perturbations. For example, the stability and vulnerability of 10-year cycle of Canadian lynx and snowshoe hare are explained in our nonlinear model. In terms of conservation law and stability, the BCF model clarifies the atto-fox problem (10^{-8}–fox problem) of Lotka-Volterra nonlinear equations, which is known as a intrinsic obstacle for applications of LV-type equations.

We hope that this study will help understand applications in ecological and symbiotic systems, activities of animals and humans in natural life.


Keywords: Lotka-Volterra equation, Conservation law and stability, Noether's theorem
ICCBES-1276
Homology Modeling and Docking Studies of Cloned Tyramine-β-Hydroxylase (TβH) from Drosophila Melanogaster

Md. Nazmul Hasan\textsuperscript{a,b}, Abdullah Zubaer\textsuperscript{c}, Mohammad Jakir Hosen\textsuperscript{d}, Hiroto Ohta\textsuperscript{a,e}, Jae Man Lee\textsuperscript{f}, Takahiro Kusakabe\textsuperscript{f} and Akinori Hirashima\textsuperscript{a}

\textsuperscript{a}Laboratory of Pesticide Chemistry, Division of Molecular Biosciences, Department of Bioscience and Biotechnology, Faculty of Agriculture, Kyushu University, Japan
\textsuperscript{b}Department of Genetic Engineering and Biotechnology, Jessore University of Science and Technology, Bangladesh
\textsuperscript{c}Department of Microbiology, University of Manitoba, Canada
\textsuperscript{d}Department of Genetic Engineering and Biotechnology, Shahjalal University of Science and Technology, Bangladesh
\textsuperscript{e}Laboratory for Biotechnology and Environmental Science, Graduate School of Science and Technology, Kumamoto University, Japan;
\textsuperscript{f}Laboratory of Silkworm Science, Kyushu University Graduate School of Bioresource and Bioenvironmental Sciences, Japan

Abstract
Biogenic amines are common biologically active substances extended within the whole animal kingdom where they play vital roles as signal transducer as well as regulator of cell functions. One of these biogenic amines called octopamine (OA) is synthesized from tyramine (TA) by the catalysis of tyramine-β-hydroxylase (TβH) originated in the insect nervous system. Both TA and OA act as neurotransmitters, neurohormones and neuromodulators in the arthropod nervous system. Herein, the inhibitory activity of 1-arylimidazole-2(3H)-thiones (AITs) was tested on cloned Drosophila tyramine-β-hydroxylase (DmTβH) expressed in Bombyx mori strain. Radiolabelled 3H-TA was used to analyze the activity of AITs exhibited inhibitory effects on DmTβH, whose ID50 values range from 0.020 nM to 2.511 µM where DmTβH was inhibited in a dose-dependent manner at pH 7.6 and 25 °C during a 30 min of incubation. To understand the catalytic role of the TβH, a three dimensional structure of the TβH from \textit{Drosophila melanogaster} was constructed by homology modeling using the Phyre2 web server with 100% confidence. The modeled three-dimensional structure of TβH was used to perform the docking study with AITs. This may give more insights to precise design of inhibitors for TβH to control insect’s population.
ICCBES-1317
Karyotype of Local and Imported Garlic (Allium sativum) in North Sumatera Indonesia

Tumiur Gultom, Artha Manurung
Departement of Biology, Faculty of Mathematics and Natural Sciences,
Medan State of University North Sumatera, Indonesia
Email: gultomtumiur1607@gmail.com

Abstract
Consumption of garlic in Indonesia comes from local production and imported. Local production using local cultivars that have been adaptive in Indonesia. Garlic imported came from China. The difference traits is in the size of the bulbs and cloves of garlic. Garlic bulb size greater import than the local. Seeing this size, the researchers wanted to know the difference at the level of chromosome to make kariotype with Squash method. The tools used in this study are flacton bottles, pipette, micropipette, tweezers, toothpick, razor blades, glass slide, cover glass, blotting paper, tissue, microscope and refrigerator. Materials used are local garlic and imported, glacial acetic acid, ethanol absolute, 1N HCl, aceto-orcein 2%, water ice and distilled water. The variables measured were the number of chromosomes, the length of the short arm (p), the length of the long arm (q), the length of the absolute chromosome (p + q), the ratio of chromosome arm (q / p), the form of chromosomes, the proportion of the long arm of chromosome pair longest and the shortest (R), intrachromosomal asymmetry index (A1), interchromosomal asymmetry index (A2), relative asymmetry index (Asl) and formula karyotype local garlic and imported based on the form of chromosomes. The results showed that local and imported garlic has the same number of chromosomes (diploid) is 2n = 16 chromosomes. Based on the size of chromosomes, local garlic has the size of the largest chromosome that is the absolute length of chromosome (p + q) ranges from 4.75 + 10 μm up to 8.16 + 10 μm. Karyotype formula on local garlic is 2n = 14 metacentris + 2 submetacentris and on imported garlic is 2n = 10 metacentris + 6 submetacentris.

Keywords: karyotype, garlic (Allium sativum), chromosome, Squash method
Abstract

Pollution has become a major worldwide problem, with heavy metals being considered as the main environmental pollutants. Not all remediation techniques introduced are environmentally friendly and cost-effective, with plants, cyanobacteria, nematodes and fungi being discovered as alternative green bioremediation agents. Among fungi as mycoremediators, mangrove fungi are suggested to have some associated roles in detoxification of heavy metals in mangrove ecosystem which is considered as heavy metal basin. It is therefore very interesting to study the mechanisms or pathways involved in the detoxification of heavy metals in a mangrove fungus *Trichoderma atroviride*, as little work has addressed this matter in mangrove fungi. Studies include the productions/expressions of proteins, genes and metabolites by the fungus upon exposure to cadmium (Cd), through works on the expression of thiol-related proteins, Differentially-Expressed Genes (DEG), 2D-gel electrophoresis protein profiling and metabolomics method using GC-MS analysis. Results showed that upon cultivation of *T. atroviride* in different concentrations of Cd to induce the response, the amount of one thiol-related protein increased as the cadmium concentration increased. For DEG technique, a total of 14 genes were differentially-expressed, with two genes identified to encode for 3’ end of Phenazine biosynthesis regulator (Pbr) and cell wall integrity and stress response component (WSC). In addition, 2D-gel electrophoresis showed four proteins being expressed, identified as
nucleoside diphosphate kinase, L-xylulose reductase and peptidyl-prolyl cis-trans isomerase, with one unidentified. GC-MS metabolomics analyses showed that stress-induced *T. atroviride* displayed a decrease in certain carbohydrate groups, while some other carbohydrates were induced, suggesting the roles of carbohydrates in cadmium toxicity regulation. Combining all results on proteins, genes and metabolites expressed, the pathways involved in *T. atroviride* as response to Cd toxicity can be elucidated. These molecules can be investigated further as potential biosensors to detect heavy metal pollution in many industries especially in wastewater treatment.

Keywords: Heavy metal, mangrove fungus, cadmium-responsive proteins, differentially-expressed genes, metabolites.

1. Background and Objectives

Fungi have been used as mycoremediators for heavy metal pollution. A range of potential mechanisms that might be involved in the detoxification and thus tolerance to heavy metal stress at the cellular level as well as gene level have been studied; for example avoiding the build-up of toxic concentrations at sensitive sites within the cell; an enhanced oxidative defence; involvement of the plasma membrane either by reducing the uptake of heavy metals or by stimulating the efflux pumping of metals and involvement of protoplast (Hall, 2002). However, less study has been done on mangrove fungi which are suggested to have some associated roles in detoxification of heavy metals in mangrove ecosystem as heavy metal basin. This study attempted three different approaches to obtain information on proteins/metabolites involved – at protein level, gene level and metabolites level. The provided insight on the response mechanism of the fungus towards cadmium (Cd) toxicity at different levels could lead to the elucidation of pathways involved in the detoxification of heavy metals in a mangrove fungus.

2. Methods

**Isolation and identification of fungi associated with mangrove in Universiti Malaysia Terengganu and Tok Bali, Kelantan:** Samples of leaves, branches and roots were gathered from six selected hosts (*Acrostichum aureum, Avicennia alba, Lumnitzera racemosa, Rhizophora apiculata, Sonneratia caseolaris and Nypa fruticans*) around University Malaysia Terengganu, washed with sea water in order to clear the mud and kept in plastics containers. Surface sterilization on samples was performed using 95% ethanol, sterile water and 5% sodium hypochlorite. Small fragments of substrates were placed on Potato Dextrose Agar (PDA) and Sea Water Agar (SWA) made from artificial sea water for direct culture technique whereas strips of samples in 10-12cm long were placed in alcohol-sterilized plastic boxes lined with filter paper, which was moisturized with sterile 15% sea water for damp incubation technique. All samples were kept in the dark at room temperature (27°C) and examined after
few days of incubation. Identification of fungal isolates was made following key references from Kohlmeyer and Kohlmeyer (1979), Barnett and Hunter (1998) and Woodward (2001).

**Screening of mangrove-fungi isolates for Cd tolerance property:** The fungal isolates were grown on Potato Dextrose Agar (PDA) with different Cd concentrations - 0µM to 500µM. The most tolerant fungus towards Cd was selected to detect the activity of thiol-related proteins as indicator to heavy metal toxicity response, using Ellman’s test for glutathione measurement.

**Expressions of related proteins using SDS-PAGE and 2D-gel electrophoresis:** The Cd-responsive proteins were extracted using method modified from Verlecar et al. (2008). The mycelium was homogenized with extraction buffer [20 mM Tris-HCl buffer, 0.5 mM phenylmethylsulphonyl-fluoride (PMSF), 0.1% (v/v) β-mercaptoethanol and 2% (w/v) polyvinyl pyrrolidine (PVP)] at ratio 1:4, followed by centrifugation (Sigma, UK) at 10,000 rpm for 45 min at 4°C. Then, the supernatants that contained Cd-responsive proteins were added with 1 ml of cold absolute ethanol (-20°C) and 80 µl of chloroform and centrifuged at 6000 rpm for 10 min at 4°C. The supernatant was mixed with three volumes of cold ethanol (-20°C) and incubated at -20°C for 1 h. After that, the supernatant was centrifuged at 6000 rpm for 10 min and the pellet was washed with 87% ethanol and 1% chloroform solution. Finally, the pellet obtained was dissolved in 5 mM Tris-HCl (pH 8.6) and 1 mM EDTA. The Cd-responsive proteins being expressed was quantified by using SDS-PAGE (Laemmli, 1970). Two-dimension (2-D) electrophoresis was also carried-out and and proteins of interest were sent for sequencing using MALDI-TOF technique.

**Differential gene expressions upon exposure to Cd:** This was carried out using Gene Fishing DEG kit by an ACP-based Polymerase Chain Reaction (PCR) method. In a PCR tube, reagents of PCR 7µl diluted first-strand cDNA (~50ng) as a template for the two stages ACP-Base Gene GeneFishing™ PCR, 2µl 5µM arbitrary ACP (one of the arbitrary ACPs), 1µl 10µM dT-ACP2, 2µl distilled water, and 10µl 2X SeeAmp™ ACP™ Master Mix were mixed together on ice to the total volume of 20µl. In each PCR reaction, a primer consisting of one of ten Arbitrary ACPs in the kit and dT-ACPs were used as the 5’ and 3’ primers. Differentially expressed bands from agarose gel were cut for further extraction step. Two gene sequences were selected to obtain clones that extended towards 5’ end by using 5’ RLM-RACE technique. From the two, protein with the most probable role in Cd toxicity response was selected further to analyse its expression upon exposure to Cd, using Real-Time quantitative polymerase chain reaction (qPCR).

**Determination of metabolites changes using Gas Chromatography-Mass Spectrometry:** A preliminary study using metabolomics approach, the GC-MS, was carried-out to determine the changes in metabolites of mangrove fungus. The fungus was grown in PDB with 0.5 mM
CdCl$_2$ for seven days. Extractions of the intracellular metabolites were done using two different solvent systems: methanol extraction and biphasic extraction (methanol-chloroform-water with 1:1:0.9 ratio). Both extracts were derivatized using MSTFA, prior to GC-MS. Principal Component Analysis (PCA) plots were analysed to obtain information on metabolites that possibly play roles in response to Cd toxicity.

3. Results

Altogether, 25 fungal species isolated from mangroves were identified, with seven aquatic species (Table 1). Out of seven aquatic fungi, only one freshwater fungus found which was *Trichoderma* sp.. The rest were marine fungi: *Koralionastes augustus*, *K. violaceus*, *Haloguignardia cystoseirae*, *Pontogeneia calospora*, *Trematosphaeria mangrovei* and *Savoryella paucispora*. In this study, Ascomycota was the most dominant phylum recorded with 19 fungi followed by five from phylum Zygomycota and one from phylum Deuteromycota.

From the screening of fungi tolerant to Cd (Table 2), the fungus that could tolerate most was identified as *Trichoderma atroviride*, which identity was confirmed further using molecular approach. Ellman’s test on *T. atroviride* showed that the amount of thiol-related proteins increased as the Cd concentration increased (Figure 1).

Apart from that, one protein also appeared as a clear increasing band on SDS-PAGE with a molecular weight of around 63.8 kDa (Figure 2) (Noor-Afiza, 2010). An attempt to identify any putative metallothionine-related gene showed that the ~150 bp PCR product has no similarity with any established phytochelatin synthase gene (data not shown). In addition, 2D-gel electrophoresis showed four proteins being expressed (Figure 3), identified as nucleoside diphosphate kinase, L-xylulose reductase and peptidyl-prolyl cis-trans isomerase, with one unidentified, which may also play roles in Cd detoxification (Premasangery et al., 2012).

For DEG technique, a total of 14 genes were differentially-expressed, with two genes identified to encode for 3’ end of Phenazine biosynthesis regulator (Pbr) and cell wall integrity and stress response component (WSC) (Figure 4). The two genes were selected further to obtain clones by using 5’ RLM-RACE technique. Both full length sequences of *Pbr* and *WSC* were successfully obtained (Nur-Faizah, et al., 2012). Only WSC protein was chosen to analyse its expression upon exposure to Cd, as it is reported to play a role in protecting cells from damage during stress, using qPCR. Results showed that WSC was expressed higher at 300 µM of Cd, in line with results obtained with DEG (data not shown).

Preliminary GC-MS metabolomics analyses showed that stress-induced *T. atroviride* displayed
a decrease in certain carbohydrate groups, while some other carbohydrates were induced, suggesting the roles of carbohydrates in Cd toxicity regulation. Principal Component Analysis (PCA) score plots showed that methanol extraction clearly separated samples from controls (Figure 5), while biphasic extraction method did not. Interestingly, sample-to-sample variation indicates that methanol extraction showed larger sample-to-sample variation between the two methods. In addition, PCA loadings plots for both methods showed few similar sugar/sugar alcohol compounds (Figure 6), which may contribute to the response of *T. atroviride* towards Cd toxicity (Siti Athirah et al., 2013).

Combining all results on proteins, genes and metabolites expressed, and with more comprehensive metabolomics data, the pathways involved in *T. atroviride* as response to Cd toxicity can be elucidated to provide understanding on the response mechanism. These molecules can also be investigated further as potential biosensors to detect heavy metal pollution in many industries especially in wastewater treatment.

3.1 Tables and Figures

<table>
<thead>
<tr>
<th>Species</th>
<th>Color of hyphae</th>
<th>Appearance of spores</th>
<th>Texture of cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Absidia corymbifera</em></td>
<td>Grey</td>
<td>white</td>
<td>fleshy</td>
</tr>
<tr>
<td><em>Acroconium sp.</em></td>
<td>White</td>
<td>white</td>
<td>downy</td>
</tr>
<tr>
<td><em>Apophysomyces elegans</em></td>
<td>white cream</td>
<td>white</td>
<td>fleshy</td>
</tr>
<tr>
<td><em>Aspergillus sp.</em></td>
<td>White</td>
<td>dark green</td>
<td>cottony</td>
</tr>
<tr>
<td><em>Aureobasidium pulullans</em></td>
<td>Brown</td>
<td>dark brown</td>
<td>moldy</td>
</tr>
<tr>
<td><em>Chaetomium globosum</em></td>
<td>White</td>
<td>white cream</td>
<td>downy</td>
</tr>
<tr>
<td><em>Chrysosporium sp.</em></td>
<td>white</td>
<td>dark green and white</td>
<td>cottony</td>
</tr>
<tr>
<td><em>Cladosporium herbarum</em></td>
<td>dark green</td>
<td>dark green</td>
<td>downy</td>
</tr>
<tr>
<td><em>Curvularia lunata</em></td>
<td>black</td>
<td>black</td>
<td>downy</td>
</tr>
<tr>
<td><em>Epicoccum nigrum</em></td>
<td>brown</td>
<td>dark brown</td>
<td>moldy</td>
</tr>
<tr>
<td><em>Fusarium pedrosei</em></td>
<td>black</td>
<td>black</td>
<td>moldy</td>
</tr>
<tr>
<td><em>Microsporum equinum</em></td>
<td>bright yellow</td>
<td>cream</td>
<td>slimy</td>
</tr>
<tr>
<td><em>Microsporum sp.</em></td>
<td>yellow cream</td>
<td>light green</td>
<td>downy</td>
</tr>
<tr>
<td><em>Mucor sp.</em></td>
<td>dark grey</td>
<td>dark grey</td>
<td>downy</td>
</tr>
<tr>
<td>Fungi</td>
<td>0</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td><em>Trichoderma</em> sp.</td>
<td>+++</td>
<td>+++</td>
<td>+++</td>
</tr>
<tr>
<td><em>T. mangrovei</em></td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><em>S. paucispora</em></td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><em>K. violaceus</em></td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><em>K. augustus</em></td>
<td>+++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td><em>H. cystoseira</em></td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td><em>P. calospora</em></td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 2: Growth rate of aquatic fungi on media with different CdCl₂ concentration.

Figure 1: The effect of various cadmium concentration on thiol contents in *T. atroviride.*
Figure 2: Expression of phytochelatin synthase upon different concentration of cadmium treatment. (a) Exposure to 0-250 μM CdCl₂. (b) Exposure to 300-500 μM CdCl₂.

Figure 3: 2D-electrophoresis of a) control sample b) treated sample with 0.5 mM CdCl₂.
Figure 4. Agarose gel photograph shows 14 expressed genes of interest for the identification of differentially-expressed genes of normal and Cd^{2+} treated *T. atroviride.*

<table>
<thead>
<tr>
<th>A. Normal</th>
<th>100μM Cd^{2+}</th>
<th>Forward primer used</th>
<th>Size (bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-9</td>
<td>400</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-14</td>
<td>250</td>
</tr>
<tr>
<td>B. Normal</td>
<td>300μM Cd^{2+}</td>
<td>Forward primer used</td>
<td>Size (bp)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-4</td>
<td>500</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-5</td>
<td>350</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-14</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-16</td>
<td>300</td>
</tr>
<tr>
<td>C. Normal</td>
<td>500μM Cd^{2+}</td>
<td>Forward primer used</td>
<td>Size (bp)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-19</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arbitrary ACP-20</td>
<td>500</td>
</tr>
</tbody>
</table>
3.2 Acknowledgements

We would like to thank the Ministry of Science and Technology (MOSTI) Malaysia for the Science Fund grant, Ministry of Higher Education (MOHE) for the FRGS grants, Institute of Marine Biotechnology UMT and the Institute of Systems Biology Universiti Kebangsaan Malaysia for financial and technical supports.

**Figure 6:** PCA loading plots from GC-MS spectra from (a) methanol and (b) methanol-chloroform-water (1:1:0.9) extractions of *T. atrorubide*. 
4. References


Proteolysis Mediated ER Exit of Neuroligin 2 Regulates Synapse Development in Drosophila

Renjun Tu\(^a\), Jinjun Qian\(^b\), Mingkuan Sun\(^c\), Wei Xie\(^d\)

\(^a\) Institute of Life Sciences, Southeast University, China
E-mail address: tu-renjun@seu.edu.cn

\(^b\) Institute of Life Sciences, Southeast University, China
E-mail address: qianjinjun@seu.edu.cn

\(^c\) Institute of Life Sciences, Southeast University, China
E-mail address: sunmingkuan800606@163.com

\(^d\) Institute of Life Sciences, Southeast University, China
E-mail address: wei.xie@seu.edu.cn

1. Background/ Objectives and Goals

Neuroligins (Nlgs) are transmembrane proteins that play essential roles in synapse development and function (Baudouin and Scheiffele, 2010; Knight et al., 2011; Südhof, 2008). Mutations in human Nlgs have been found to be associated with autism (Jamain et al., 2003). Nlg1 undergoes activity dependent proteolysis by ADAM10/MMP9 on synapses in rodent species, which may negatively regulate synapses remodeling (Peixoto et al., 2012; Suzuki et al., 2012). The C-terminal fragment (CTF) of Nlg1 was subsequently cleaved by presenilin/γ-secretase (Suzuki et al., 2012), and then regulates spines and synaptic plasticity via LIMK1/cofilin-mediated actin reorganization (Liu et al., 2016). However, the proteolysis mechanisms and functions of other Nlgs are not clear.

2. Methods

We use Drosophila as research model to study the roles of Neuroligin 2 proteolysis. First, we use immunoblotting to investigate the cleavage of Drosophila Neuroligin 2 (DNlg2) in different samples. Second, we use overlap-PCR induced mutation to generate a series of sequence mutant DNlg2 constructs. Third, we transform these mutant constructs into S2 cells to mapping the cleavage region. Fourth, we use density gradient separation to identify which organelle is responsible for the cleavage of DNlg2. Fifth; we generate several mutant-DNlg2 transgenes and then use immunostaining to investigate synapse development and intracellular localization of DNlg2. At last, we use co-immunoprecipitation in identify the potential proteins which can interact with DNlg2.
3. Expected Results/ Conclusion/ Contribution

Our results surprisingly demonstrate that DNlg2 is ubiquitously cleaved in endoplasmic reticulum (ER), rather than on synapse surface. The proteolysis processing generates a soluble ~47kDa N-terminal fragment (NTF) and a membrane-tethered ~70 kDa CTF in vivo as well as in S2 cells cultures. We show by mutational analyses that a region encompassing Y642-T698 is required for DNlg2 proteolysis. Particularly, we find that non-cleavable DNlg2 is retained in ER. Overexpression of full-length DNlg2 rather than CTF can increase the expression level of an ER protein Bip. At the same time, the full-length or noncleavable DNlg2 but not CTF can interact with Bip (Haas, 1994); suggest Bip is responsible for the ER retention of noncleavable DNlg2. Overexpression of DNlg2-CTF can rescue neuromuscular junction and GluRIIB defects in dnlg2 mutants, suggest CTF contributes to maintain synapse development. Furthermore, autism associated R598C (Comoletti et al., 2004) mutation in DNlg2 leads to severe defects in proteolysis and ER exit, suggesting that perturbed proteolysis of Nlgs may be one of the mechanisms underlying autism. To our surprise, we find that the NTF and CTF of DNlg2 remain associated noncovalently after proteolysis; and then NTF can be released into matrix in a calcium dependent manner. However, the precise physiological functions of DNlg2-NTF remain need to be further studied. Altogether, our data demonstrate that the proteolysis of DNlg2 initiates its ER exit and maturation, which is required for synapse development. Our study provides a significant advancement in understanding the diverse mechanisms and functions of Nlgs’ cleavage, and one potential autism pathogenesis.

Keywords: Neuroligin, proteolysis, ER exit, autism, synapse

References


ICCBES-1115
Simple and Rapid Determination of Norfloxacin Using Paper-Based Platforms in Food and Pharmaceutical Samples

Kwanchanok Wanawananon, Kanyarak Prasertboonyai, Narabhats Rannurags, Saisunee Liawruangrath
Alpha Flow Analysis Group, Department of Chemistry and Center of Excellent for Innovation in Chemistry (PERCH-CIC) Together with Materials Science Research Center, Faculty of Science, Chiang Mai University, Thailand
E-mail addresses: scislwrn@gmail.com; saisunee_l@cmu.ac.th

Abstract
A micro total analysis system is described for the determination of norfloxacin. The paper-based microfluidic analysis system with micro electrode was designed and fabricated via a wax dipping method. The paper-based analysis devices (PADs) (system was prepared using Whatman No.1 filter paper. The wax dipping method was used to fabricate hydrophilic hollow channel and hydrophobic barrier to allow analyte solution diffusion to detection zone. The detection system was homemade MWCNTs working micro electrode coupled with electroanalytical method. Norfloxacin can be determined by measuring their oxidation peak current. A linear relationship between the oxidation peak current and norfloxacin concentration was obtained over the concentration range of 0.5-10.0 mg L\(^{-1}\) norfloxacin with a correlation coefficient \(r^2\) of 0.9967. The limit of detection (LOD) (defined 3\(\sigma\)) was 0.38 mg L\(^{-1}\) together with the limit of quantitation (LOQ) (of 0.61 mg L\(^{-1}\) for norfloxacin. The relative standard deviations (%RSD) (of 2.0 mg L\(^{-1}\) norfloxacin was 4.53) \(\%n=11\). The proposed PADs system incorporates homemade micro electrode reduces reagent consumption and waste production and could thus be considered to be more environmentally friendly.

Keywords: Green chemistry, Norfloxacin, Carbon Nanotubes, voltammetry, paper-based microfluidic device

1. Introduction) Background/Objectives and goals
Due to scientific and public concern about the environment pollution, environmentally friendly practices have been introduced in different areas of society and research. In green analytical chemistry, the main principles are to replace toxic reagents, to miniaturize and to automate methods, making it possible to reduce dramatically the amounts of reagents consumed and wastes generated, so reducing or avoiding side effects of analytical methods. [1] [With this background, Green Analytical Chemistry] GAC (started as a search for practical alternatives to the off-line treatment of wastes and residues in order to replace polluting methodologies with clean ones. Green Chemistry is the use of chemistry techniques and methodologies that reduce...
or eliminate the use or generation of feed stocks, products, by-products, solvents, reagents, etc. that are hazardous to human health or the environment [2]. The microfluidic system (also called lab on a chip, micro flow analysis or micro total analytical system) μTAS, is one of the green analytical chemistry techniques that are rapid, highly sensitive, low reagent and sample consumption, low waste production and cost effectiveness[3]. Moreover, it relates to the miniaturization of all function in chemical analysis, such as sampling, removal of interferences, small amount of chemical consumption, and small size of mixing and reaction chamber. The entire chemical measurement device could be miniaturized onto a few squares centimeters. The reduction in device size also allows for increasing flexibility resulting in location of instruments at or near the site of use.

Various materials such as silicon [4], quartz [5], glass [6], metals [7], polymers [8] and paper [9] have been used to construct micro reactors. Important considerations in material choice include chemical compatibility, ease and reproducibility of fabrication, whether or not the material supports electro-osmotic flow (EOF) with the solvents of interest and compatibility with detection methods [10]. Paper-based analytical devices (PADs) have been introduced [11] by a landmark study of the whitesides’s group at Harvard University in 2007 as a low-cost alternative for quantitative chemical measurement. Relative to traditional assays, PADs are easy to operate, consume small reagent volumes, low cost, simple disposal, portability and provide rapid results typically in min [12-15]. Paper-based analytical devices can be easily constructed by inserting hydrophobic walls on paper [16, 17]. Several methods are available for patterning channels of hydrophilic surfaces on filter paper with different costs and resolution [18]; Wax dipping is a simple, rapid and cheap fabrication technique that also provides good resolution and repeatability [19]. This method involves a single step and requires only a hot plate for patterning hydrophilic and hydrophobic areas. Moreover, Wax is a material generally used worldwide because it is inexpensive and non-toxic. The movement of liquid samples within the hollow channels is governed by capillarity so this device does not require the use of pipettes, syringes, needles, pumps, chromatographic or electric energy [1]. Therefore, paper-based analytical devices can provide quick results and uncomplicated analysis, without the need for a full laboratory setting.

Norfloxacin is an important antibacterial agent developed in the 1980s. These quinolonas are effective against gram-positive and gram-negative bacteria through selective inhibition of bacterial DNA synthesis [20-21]. It is the first choice drug for the treatment of diseases caused by Campylobacter, E. coli, Salmonella, Shigella and V. colera [22]. Norfloxacin is approved to use in a wide range of gastrointestinal, urinary, respiratory tract, prostatitis, sexually transmitted diseases and ocular and skin infections [23]. It is also used in patients with intra-abdominal infections in combination with antianaerobic agents. In general, fluoroquinolones are well tolerated, with most side-effects being mild to moderate. On occasion,
serious adverse effects occur. Common side-effects include gastrointestinal effects such as nausea, vomiting, and diarrhea, as well as headache and insomnia. Susceptible groups of patients, such as children and the elderly, are at greater risk of adverse reactions during therapeutic use.

In this work, a new paper-based microfluidic device has been fabricated using home-made MWCNTs paste as a working electrode for electrochemical analysis of norfloxacin in food and pharmaceutical samples.

2. Materials and Method

2.1 Apparatus
Cyclic voltammetry (CV) and differential pulse voltammetry (DPV) were performed with EChem v.2.1.13 software using a potentiostat EDAQ EA161, Australia.

Whatman No.1 filter paper was purchased from GE Healthcare, Ltd. England. (White paraffin and Polymethylmethacrylate sheet) 1 mm thick were purchased from a local area shop in Chiang Mai, Thailand. Magnetic sheet 1 mm thick (and permanent magnets was purchased from a stationary shop in Chiang Mai, Thailand.

2.2 Reagents and Solutions
All chemicals were of analytical reagent grade and were used without further purifications. All solutions were prepared with distilled deionized water obtained by a system of Milli-Q Millipore, USA.

MWCNTs was obtained from Department of Physics, Chiang Mai University, Thailand (and silver conducting paste was purchased from Sigma-Aldrich, South Korea. Poly Vinyl Chloride was obtained from Sigma-Aldrich, UK and prepared in acetone, cyclohexanone.) Sigma-Aldrich, UK (mix solution.

A stock solution of norfloxacin 1000 mg L\(^{-1}\) (was prepared by dissolving 0.1000 g of norfloxacin) Sigma, USA (with 100 mL distilled deionized water and the working solutions were obtained by dilution with potassium chloride solution. The stock solution was prepared daily to avoid decomposition.

A 0.5 M potassium chloride) Fluka, USA, which served as a supporting electrolyte, was prepared by dissolving 19.6053 g of KCl in water in 500 mL volumetric flask.

2.3 Wax dipping fabrication method
A pattern of PADs hollow channels was designed with 2.0 mm wide and 36.0 mm long. Pattern of hollow channel had one inlet and one outlet holes for solution in and out. At the end of
hollow channel had three branch) 2.0 mm wide and 14 mm long (for working, auxiliary and reference electrodes. After that, this pattern was engraved onto magnetic sheet with CNC machine to be mould for the following step. This mould can be repeatedly used to produce numerous pieces of paper based microfluidic devices.

For the wax dipping method, paraffin wax was put in a beaker and heated until they melted using a hotplate. To ensure that the temperature was kept in the range of 125 - 135 °C, the temperature was monitored throughout the experiment by means of a thermometer. Whatman No.1 paper was cut into a 3.0 cm × 5.0 cm piece and placed onto a PMMA plate. Then, the mould was put onto the paper, and it was temporarily attached by means of magnetic force using a permanent magnet placed on the backside of the PMMA plate. Next, the assembly was dipped into a chamber of melted wax for 1 s. After the paper was cooled to room temperature, it was peeled off, and the mould was removed from the paper. The wax-dipping fabrication process for the PADs is shown in Figure 1. The wax dipping method uses melted wax to coat a hydrophobic barrier onto paper while the hydrophilic channel is protected by mould. When the paper was dipped into the melted wax, the melted wax penetrated into the membrane of the paper whereas the area obscured by the mould did not absorb the melted wax. Therefore, patterns of hydrophobic and hydrophilic areas were generated on paper. By wax dipping fluid could retain within the hydrophilic channel; therefore, this area could be used for the experiment.

2.4 Sensors construction
For the electrodes preparation, MWCNTs paste was used as the working electrode (WE) and the counter electrode (CE); Silver conductive paste was used as the reference electrode (RE). MWCNTs paste electrode was prepared by mixing an accuracy weight of MWCNTs with PVC solution in 1:1 acetone and cyclohexanone (and continuous stirred until a homogeneous mass was obtained.

In this case, all electrodes were stencil-screened on patterned paper and then were cured at room temperature. The paper-based device designed in this study for electrochemical detection is shown in Figure 2.

2.5 Application of PADs with electrochemical method
The solutions of KCl was prepared and used as the supporting electrolyte because it could react with the surface of Ag paste electrode to create the Ag/AgCl reference electrode. The solutions of norfloxacin were prepared from stock solution diluted with KCl solution, mixed well and then analyte solutions were transferred into the inlet reservoir. Then the cell was allowed to equilibrate for another 10-15 min before electrochemical measurement. After that cyclic
voltammogram of Norfloxacin and the KCl blank solutions were scanned over a range of -1.0 to 1.5 V vs Ag/AgCl at a scan rate 100 mV/s using EDAQ potentiostat and the signals were recorded with the Echem 2.1.13 software.

The differential pulse voltammetry method was used for quantitative analysis. The standard or sample solution containing norfloxacin was dropped into inlet reservoir. Then it was allowed to equilibrate for another 10-15 min. The solutions flowed to detection area by capillary force. The oxidation current of norfloxacin was detected compared with Ag/AgCl reference electrode in the potential range of 0 to 0.9 V.

2.6 Sample Preparation
Twenty tablets were powdered and a quantity of the powder equivalent to 25 mg of the norfloxacin was extracted by shaking with 30 mL water, followed by another two extractions, each with 20 mL of water. The extracts were filtered through Whatman No. 41 filter-paper into a 100 mL volumetric flask and then diluted to volume with water.

Fish samples were collected from open market in Chiang Mai Province, Thailand. Approximately 1 g (accurately weighed) of homogenized fish samples were weighed into digestion vessel a mixture of 1.0 mL, 2.0 mL HNO₃-HClO₄ (1:1) and 5.0 mL H₂SO₄ were added. The mixtures were then heated at a temperature at 250 °C in an oven until the solutions were clear. After standing them to cool to room temperature the samples were transferred into each separated 50 mL volumetric flask and made up to the mark with deionized distilled water. In order to obtain optimum conditions, the samples were added with potassium chloride and alizarin under optimum concentrations. Finally, it was mixed well and subsequently analyzed by the proposed method as described above and the results were evaluated. HPLC was applied as reference method.

3. Results and Discussion
3.1 Electrochemical behavior of norfloxacin
The electrochemical behavior of MWCNTs paste electrode was studied by cyclic voltammetry. The cyclic voltammetry of potassium chloride supporting electrolyte solution was examined. No peak was registered for the micro electrodes on PADs. For norfloxacin in potassium chloride solution was investigated over a range from -1 to 1.5 V versus Ag/AgCl reference electrode, using potentiostat operating at differential pulse voltammetry mode. It was found that norfloxacin exhibited an oxidation peak in a range of 0 to 0.9 V as shown in Figure 3. Therefore, the potential of 0 to 0.9 V versus Ag/AgCl reference electrode (was chosen for the quantitative analysis in differential pulse voltammetry.

3.2 Effect of Differential Pulse Voltammetric Parameters
Differential pulse voltammetry is the technique typically used to quantitative detection and/or determination of a given electrochemical active analyte, and so differential pulse voltammetry on this paper device was tested for norfloxacin detection. The differential pulse voltammogram of norfloxacin was clearly observed in the range of 0 to 0.9 V vs Ag/AgCl. To obtain the optimal conditions for the quantitative analysis, 1 ppm of norfloxacin in potassium chloride was used throughout the optimization of experimental conditions approach.

For differential pulse voltammetry, the effects of the pulse amplitude and step potential on the peak current were examined. Initially the pulse amplitude was varied from 25 to 200 mV, where the peak currents of norfloxacin increased as the pulse amplitude increased (Figure 4), additionally, peak broadening was also observed. Therefore, the pulse amplitude of 50 mV was chosen as a trade-off between the peak height and peak broadening.

Then, the effect of the step potential was evaluated over the range of 2 mV to 10 mV, where the optimal value was found to be 6 mV because above 6 mV the slight increment in the peak intensity was observed (Figure 5). Consequently, these pulse amplitude 50 mV (and step potential) 6 mV were chosen as the optimum electrochemical conditions.

3.3 Effect of MWCNTs paste concentration
The conductivity of norfloxacin in potassium chloride solution is greatly increased in the enlargement of MWCNTs concentration. Sufficient MWCNTs can form effective conductivity electrode for norfloxacin determination. In order to obtain the greatest conductivity, the MWCNTs concentration should be optimized. The influence of MWCNTs concentration on the determination of norfloxacin was studied at different values in the range of 2.0 g L\(^{-1}\) to 16.0 g L\(^{-1}\). The results were shown in Figure 6 that the sensitivity increased with increasing MWCNTs concentration up to 12.0 g L\(^{-1}\). After that, the sensitivities decreased rapidly. High concentration of MWCNTs caused heterogeneous solution and aggregation of dried MWCNTs electrode that obstructed electron transfer in working electrode. Therefore, a MWCNTs concentration of 12.0 g L\(^{-1}\) was fixed for subsequent experiments for norfloxacin determination.

3.4 Effect of PVC concentration in MWCNTs paste
The effect of PVC concentrations in MWCNTs paste on the sensitivity was investigated at various PVC concentrations from 2.0% m/v to 10.0% m/v. The results are presented in Figure 7. It was found that sensitivity increased from 2.0% m/v to 6.0% m/v. After that, the sensitivities decreased rapidly. These might be due to the fact that non-conducting PVC is a binder in the paste and PVC concentration effected to texture of the paste. The appropriate concentration can form homogeneous solution. The PVC concentration beyond 6.0% m/v the conductivity decreased rapidly indicating that the excess concentration of PVC has high viscosity. Cluster of MWCNTs was occurred and oxidation peak current was decreased.
Consequently, to reduce non-conductivity component in this paste a concentration of 6.0 %m/v was chosen as the optimum PVC concentration.

3.5 Effect of Potassium Chloride concentration
In electrochemical detection method, the supporting electrolyte concentration has a significant impact on the ionization and redox reaction of each analyte. Therefore, optimization of KCl concentration was performed for the electrochemical detection of norfloxacin. The effect of KCl concentration on the oxidation current was examined in the range of 0.1 mol L$^{-1}$ to 0.8 mol L$^{-1}$. The results are presented in Figure 8. It was found that conductivity increased rapidly from 0.1 mol L$^{-1}$ to 0.3 mol L$^{-1}$ KCl and that the sensitivity began to increase slightly. After that, the conductivity remained constant. To reduce reagent consumption and side-effect in electrochemistry determination, a KCl concentration of 0.3 mol L$^{-1}$ was chosen as the optimum reagent concentration.

3.6 Effect of Sample Volume
The influence of sample volume was investigated by aspirating different volumes (10-50 µL) of norfloxacin solutions into the system via an inlet reservoir. The results are shown in Figure 9. As would be expected the sensitivity increased as the sample volume increased. However, at above 30 µL peak broadening was also observed owing to the larger dispersion was obtained as soon as the sample volume was increased to some extent. In order to reach a reasonable compromise between sensitivity and response time a sample volume of 30 µL was considered to be optimum value.

3.7 Analytical performances for electrochemical detection of norfloxacin
The norfloxacin solutions were investigated by DPV under optimal conditions. Defined peaks with currents proportional to the norfloxacin concentration in the applied standard were observed as shown in Figure 10. It was found that the calibration curve was linear over the range of 0.5-10.0 mg L$^{-1}$, which was expressed by the regression equation $y=4.3196x+0.1486$ \( r^2=0.9967 \) (where $y$ is oxidation peak current of norfloxacin and $x$ is norfloxacin concentration in mg L$^{-1}$ after subtraction of blank). The limit of detection (LOD) was obtained at concentration as low as 0.38 mg L$^{-1}$, based on a signal-to-noise ratio S/N (of 3, and the limit of quantization (LOQ) at 0.61 mg L$^{-1}$ based on S/N of 10. The relative standard deviation (%) RSD (was 4.53) \( \%n=11 \) (for 2.0 mg L$^{-1}$ of norfloxacin standard solutions.

3.8 Real sample analysis
In order to determine the accuracy and precision of the method, three commercial tablets and nine different fish samples were analyzed for their norfloxacin contents by the recommended voltammetric method after appropriate sample preparation procedure. Typical analytical results correspond to the mean values of three replicate determinations are summarized in Table 1.
The accuracy of the developed electroanalytical method with Paper-based analytical device was verified by comparing the analytical results obtained by DPV method with that obtained by high-performance liquid chromatography (HPLC) method for the same samples. The agreement of the compared result was tested by the student’s t-test statistical approach. The means of both analytical methods were found to be not differ significantly, since all the calculated t-test values were less than the theoretical value \( t_{4.30} \) at the 95% confidence level. There is no statistical evidence that the means result of the proposed voltammetric method differ significantly from those of the reference method.

4. Conclusions

A practical, rapid, cost effective, accurate method for the norfloxacin determination of norfloxacin was successfully developed using a paper-based analytical device with electrochemical detection method. The fabrication procedure is simple, cost-effective and reproducible and the resulting self-made device has been adopted as a basis for developing a novel method for norfloxacin determination using differential voltammetry. The performance of the developed method using the fabricated device was tested for determining the standard drug solution. It is shown that method has good analytical performance. The differential pulse voltammetry provided a well-defined oxidation peak of norfloxacin. The applicability of the developed sensor in real samples has proven by the detection of norfloxacin in selected food and pharmaceutical samples. This platform has shown an effective technique for reduced chemical and reagent consumption. As a result, this technique provides a green chemistry method for norfloxacin determination. Therefore, it is suitable for routine analysis for quality control in industries e.g., drug and food industries. With suitable slight modification, the device could be applied for analyzing a wide range of real samples.
Table 1  Comparative determination of norfloxacin in fish and commercial tablets samples by proposed PADs method and HPLC.

<table>
<thead>
<tr>
<th>Samples</th>
<th>Concentrations (mg L(^{-1}))</th>
<th>PADs</th>
<th>HPLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norfloxacin tablet(^1)</td>
<td></td>
<td>408.14</td>
<td>403.87</td>
</tr>
<tr>
<td>labeled amount 400 mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norfloxacin tablet(^2)</td>
<td></td>
<td>395.67</td>
<td>394.87</td>
</tr>
<tr>
<td>labeled amount 400 mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Norfloxacin tablet(^3)</td>
<td></td>
<td>398.12</td>
<td>404.35</td>
</tr>
<tr>
<td>labeled amount 400 mg</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish(^1)</td>
<td></td>
<td>ND(^*)</td>
<td>ND(^*)</td>
</tr>
<tr>
<td>Fish(^2)</td>
<td></td>
<td>ND(^*)</td>
<td>ND(^*)</td>
</tr>
<tr>
<td>Fish(^3)</td>
<td></td>
<td>0.241</td>
<td>0.229</td>
</tr>
<tr>
<td>Fish(^4)</td>
<td></td>
<td>1.224</td>
<td>1.148</td>
</tr>
<tr>
<td>Fish(^5)</td>
<td></td>
<td>ND(^*)</td>
<td>ND(^*)</td>
</tr>
<tr>
<td>Fish(^6)</td>
<td></td>
<td>0.854</td>
<td>0.981</td>
</tr>
<tr>
<td>Fish(^7)</td>
<td></td>
<td>1.571</td>
<td>1.334</td>
</tr>
<tr>
<td>Fish(^8)</td>
<td></td>
<td>0.752</td>
<td>0.687</td>
</tr>
<tr>
<td>Fish(^9)</td>
<td></td>
<td>1.745</td>
<td>1.821</td>
</tr>
</tbody>
</table>

\(^*\)average of triplicate results

\(^*\)not detected
Figure 1 Fabrication process of the PADs using the wax dipping method (A) Magnetic mould for wax dipping and sensors construction (B) Procedure for patterning paper in top view (C) Lateral view.

Figure 2. Fabricated paper-based analytical device with micro electrode.

Figure 3 The cyclic voltammetry of norfloxacin measured in range of potential -1 mV to 1.5 mV (versus Ag/AgCl reference electrode).
**Figure 4.** Relationship between pulse amplitude and oxidation peak current of norfloxacin by the proposed method.

**Figure 5.** Relationship between step potential and oxidation peak current of the proposed method.

**Figure 6.** Relationship between concentration of MWCNTs and oxidation peak current of norfloxacin by the proposed method.
Figure 7. Relationship between concentration of Poly Vinyl Chloride and oxidation peak current of norfloxacin by the proposed method

Figure 8. Relationship between concentration of potassium chloride solution and oxidation peak current of norfloxacin by the proposed method

Figure 9. Relationship between sample volume and reduction peak current of norfloxacin by the proposed method
Acknowledgements

The authors would like to gratefully acknowledge the Thailand Research Fund (TRF) and The Royal Golden Jubilee (RGJ) Ph.D. Program for financial support. Our sincere thanks are also expressed to Materials Science Research Center, Department of Chemistry, Faculty of Science and the Graduate School Chiang Mai University for their partial supports. Special thanks are also expressed to Assoc. Prof. Dr. Pisith Singjai for kindly MWCNTs support.

References


Figure 10. The differential pulse voltammogram of standard norfloxacin solution in concentration range of 0.5 mg L⁻¹ to 10.0 mg L⁻¹.
Chemical Sciences (1)

Thursday, May 12, 2016 10:30-12:00  Room 1007

Session Chair: Prof. Alfred Antony Christy

ICCBES-1047
Glucose-Derived Nitrogen-Doped Hierarchical Hollow Nest-Like Carbon Nanostructure from a Novel Template-Free Method as an Outstanding Electrode Material for Supercapacitors
Jiyuan Liang | National Tsinghua University
Chun-Chieh Wang | National Tsinghua University
Shih-Yuan Lu | National Tsinghua University

ICCBES-1070
Ternary Liquid-Liquid Equilibria of Dimethyl Carbonate + 2-Methyl-1-Propanol and 2-Methyl-2-Propanol + H2O Systems AT 303.15 and 313.15 K
Rizqy Romadhona Ginting | Sepuluh Nopember Institute of Technology (ITS) Surabaya
Asalil Mustain | State Polytechnic of Malang
Gede Wibawa | Sepuluh Nopember Institute of Technology (ITS) Surabaya

ICCBES-1084
Removal of Volatile N-Nitrosamines from Tobacco Smoke Using Local Natural Zeolites
Imeda Rubashvili | Ivane Javakhishvili Tbilisi State University
Luba Eprikashvili | Ivane Javakhishvili Tbilisi State University
Teimuraz Kordzakhia | Ivane Javakhishvili Tbilisi State University

ICCBES-1094
Thermally Induced Dehydration of Castor Oil Studied by Infrared Spectroscopy and Gas Chromatography
Alfred Antony Christy | University of Agder

ICCBES-1105
Energy Efficiency Improvement of Integrated Biomass Gasification Fuel Cell Power System
Woranee Paengjuntuek | Thammasat University
Jitti Mungkalasiri | National Science and Technology Development Agency
ICCBES-1244
Monitoring of D-Penicillamine in Aqueous Environmental Samples Based on Inhibitory Kinetic Method as an Analytical Tool
Masafumi Yoshida | Tokyo City University
Surendra Prasad | The University of the South Pacific
ICCBES-1047
Glucose-Derived Nitrogen-Doped Hierarchical Hollow Nest-Like Carbon Nanostructure from a Novel Template-Free Method as an Outstanding Electrode Material for Supercapacitors

Jiyuan Liang, Chun-Chieh Wang, Shih-Yuan Lu
Department of chemical engineering, National Tsinghua University, Taiwan
E-mail address: sylu@mx.nthu.edu.tw

One of the key issues associated with carbon based supercapacitors is the further improvement of specific capacitances to boost their energy densities. In addition to capacitances, electrode kinetics, especially high rate capability, is also an essential factor to consider for designing an outstanding supercapacitor electrode for practical applications. In this paper, nitrogen-doped hierarchical hollow nest-like carbon (NHHNC) nanostructures were fabricated from glucose with a novel template-free method. A hollow nest-like precursor, Ni(OH)₂@N-polysaccharide, was first formed through a hydrothermal treatment of glucose in the presence of NiSO₄ and hexamethylenetetramine (HMT), with glucose serving as the carbon source, HMT as the precipitant and nitrogen source, and NiSO₄ as the main structure-directing reagent. The hierarchical porous carbon structure was created through thermal carbonization and activation followed by acid etching, of the hollow nest-like precursor. The NHHNC was a hierarchical porous structure composed of three-dimensionally intercepting N-doped porous carbon sheets and possessed micropores, mesopores, and macropores. This unique hierarchical hollow nest-like porous structure is ideal for applications as electrodes for supercapacitors, with the micropores offering large surface areas to accommodate electric double layer capacitances, the mesopores as fast ion transport channels, and the macropores as the electrolyte reservoir for fast ion supply. These advantageous structural features, together with the fast charge transport ability of the partially graphitized carbon sheets and extra pseudocapacitances generated through superficial redox reactions of the N-doped sites, led to outstanding capacitive performances of the NHHNC. The NHHNC electrode exhibited a high specific capacitance of 322 F g⁻¹ at 1 A g⁻¹, an excellent high rate capability of 54% capacitance retention at 20 A g⁻¹, and an outstanding cycling stability of only 2% loss in specific capacitance after 10 000 cycles at a current density of 10 A g⁻¹, among the best reported. The present template-free process, however, unlike the often cumbersome templating ones, is well suited for mass production and thus practical applications.

Keywords: glucose, template-free, hierarchical porous carbon, nitrogen-doped, supercapacitor.
ICCBES-1070

Ternary Liquid-Liquid Equilibria of Dimethyl Carbonate + 2-Methyl-1-Propanol and 2-Methyl-2-Propanol + H₂O Systems AT 303.15 and 313.15 K

Rizqy Romadhona Ginting, Gede Wibawa*
Department of Chemical Engineering, Faculty of Industrial Technology, Sepuluh Nopember Institute of Technology, Kampus ITS Sukolilo, Indonesia
* E-mail address: gwibawa@chem-eng.its.ac.id

Research regarding gasoline additives has increased progressively in recent years after methyl tert-butyl ether (MTBE) as common gasoline additives was found to be carcinogenic and polluting the groundwater. Dimethyl Carbonate (DMC) as co-additive in conjunction with butanol has been proposed as prospective alternative to replace the use of MTBE. Blended gasoline may absorb water from atmosphere during distribution and storage system, which could cause phase-splitting along with increasing corrosion rate and fuel consumption of vehicles. To prevent this problem, accurate liquid-liquid equilibria (LLE) data and knowledge have become a necessity. In this work, LLE data of DMC + 2-methyl-1-propanol and 2-methyl-2-propanol + H₂O systems were accurately measured at 303.15 and 313.15 K under atmospheric pressure.

The main experimental apparatus are equilibrium cell equipped with heating jacket, Polyscience 9102 Temperature Controller with accuracy of 0.01 K and Autonics RTD Pt100 with temperature measurement accuracy of 0.3%. The experiment was started by adding 30 cm³ of ternary mixture with known composition into equilibrium cell and stirred vigorously for 4 hours at constant temperature. It was then allowed to settle for 20 hours to ensure complete phase separation. At the end of settling period, samples were taken carefully from the organic and aqueous phase. The composition of each phase were analyzed using Shimadzu Gas Chromatography 2010 Plus. The uncertainty of the tie-line data measurements was estimated to be 0.1% in mole fraction. The experimental tie-line data were then correlated using Non-Random Two Liquid (NRTL) and Universal Quasi-Chemical (UNIQUAC) activity coefficient models.

The experimental tie-line data were proved to be reliable using Bachman-Brown correlation giving r-squared value greater than 0.999 for both systems. The experimental data for (DMC + 2-methyl-1-propanol + H₂O) system exhibit Treybal’s type II ternary phase behavior, while (DMC + 2-methyl-2-propanol + H₂O) system exhibit Treybal’s Type I due to stronger effect of hydroxyl group (at C-2) compared to hydrocarbon chain in 2-methyl-2-propanol molecular structure. In the range of temperature studied, no significant effects on phase boundary were
observed for both systems. Comparison of the experimental data with calculated result using NRTL & UNIQUAC activity coefficient models for (DMC + 2-methyl-1-propanol + H2O) system give RMSD value of 0.8 and 0.7 %, respectively, while (DMC + 2-methyl-2-propanol + H2O) system gives RMSD value of 0.7 and 0.6 %, respectively.

Keywords: dimethyl carbonate, gasoline additives, liquid-liquid equilibria, oxygenated compound

Acknowledgement
This research was supported by Indonesia Endowment Fund for Education under contract No: PRJ-1707/LPDP/2014.
ICCBES-1084
Removal of Volatile N-Nitrosamines from Tobacco Smoke Using Local
Natural Zeolites

Imeda Rubashvili, Luba Eprikashvili, Teimuraz Kordzakhia
Petre Melikishvili Institute of Physical and organic Chemistry of Ivane Javakhishvili Tbilisi
State University, Tbilisi, Georgia
E-mail address: rubashvili@yahoo.fr

1. Background
Development of modern industry causes increasingly serious pollution of the environment where human lives, constituting a health risk including cancer. Anti-cancer is thus one of the challenges faced by the scientists in 21st century and removal of carcinogen from environment is an important step. N-nitrosamines are the most widespread carcinogen compounds.

The present research has been shown the possibility of use of Georgian natural zeolites – mordenite and clinoptilolite modified H-forms for removal of nine volatile N-nitrosamines from tobacco mainstream smoke. Previously, adsorption properties of the above-mentioned zeolites modified H-forms were investigated towards volatile genotoxic compounds as sorbates - nine volatile N-nitrosamines namely N-nitrosodimethylamine - NDMA, N-nitrosomethylethylamine - NMEA, N-nitrosodiethylamine - NDEA, N-nitrosodipropylamine - DPNA, N-nitrosodibutylamine - NDBA, N-nitrosopiperidine - NPIP, N-nitrosopyrrolidine - NPYR, N-nitrosomorpholine - NMPA, N-nitrosodiphenylamine – NDPA.

2. Methods
It was constructed specially dynamic type laboratory equipment for adsorption study of N-nitrosamines on zeolites modified H-forms which was composed of the following parts: 1. Quartz tube for burning tobacco; 2. Specially made glassware with bubbler on glacial bath for n-nitrosamine absorption; 3. Vacuum pump. The smoke from tobacco burning in quartz tube was conducted through organic solvent which absorbs all N-nitrosamine compounds without any loses. A new, rapid and effective analytical GC-MS method of quantitative determination of volatile N-nitrosamines was developed and validated to control the concentrations of the above-mentioned toxic compounds in test solutions obtained from tobacco smoke. The method was validated with respect to robustness, system suitability test, specificity, linearity-range, accuracy, precision (intra-day and inter day), limit of detection (LOD) and quantitation (LOQ).

The chromatographic analysis was performed using Agilent 6890 - Inert MSD 5975 Quadrupole GC-MS System and the Carbowax/20M (30 m x 0.25 mm x 0.25µm) column (Agilent Technologies, USA).
3. Results
Analytical data has been shown that studied mordenite modified H-form’s adsorptive capability is better than clinoptilolite H-form, more precisely; mordenite H-form decreases the content of volatile N-nitrosamines in tobacco smoke to 74 % and clinoptilolite H-form decreases to 63 %. This phenomenon gives the perspective of creation “ant-nitrosamine” cigarette.

Table 1. The analytical data of N-nitrosodimethylamine - NDMA, N-nitrosomethylethylamine - NMEA, N-nitrosodiethylamine - NDEA

<table>
<thead>
<tr>
<th>Analytical Parameter</th>
<th>NDMA</th>
<th>NMEA</th>
<th>NDEA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Concentration in test solution, µg/mL</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On mordenite H-form</td>
<td>0.565</td>
<td>0.283</td>
<td>0.225</td>
</tr>
<tr>
<td>On clinoptilolite H-form</td>
<td>0.652</td>
<td>0.335</td>
<td>0.339</td>
</tr>
<tr>
<td>Without zeolite</td>
<td>1.884</td>
<td>0.827</td>
<td>0.949</td>
</tr>
<tr>
<td><strong>Amount of N-nitrosamine, ng per cigarette</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On mordenite H-form</td>
<td>102</td>
<td>51</td>
<td>41</td>
</tr>
<tr>
<td>On clinoptilolite H-form</td>
<td>119</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>Without zeolite</td>
<td>330</td>
<td>145</td>
<td>166</td>
</tr>
</tbody>
</table>

Reference

Keywords: N-nitrosamine, Zeolite, GC-MS
Thermally Induced Dehydration of Castor Oil Studied by Infrared Spectroscopy and Gas Chromatography

Alfred A. Christy
Department of Science, Faculty of Engineering and science, University of Agder, Norway
E-mail address: alfred.christy@uia.no

Abstract
The formation of the conjugated linoleic acids (CLAs) and linoleic acid isomers has been observed during thermal induction of castor oil at 250, 275 and 300 °C. Heat treated samples were analyzed by using infrared spectroscopy and gas chromatography. The variety and concentration of isomers formed in the mixture varied depending on the temperature and duration of heating experiment. The objective of this study was to find the progress of the formation of CLA isomers by dehydration of castor oil with different temperature and heat exposing time.

Hundred milligram (100 mg) portions of castor oil were placed in micro glass ampoules, sealed using oxygen and propane then subjected to the thermal treatment. The glass ampoules were removed at regular time intervals, cut open, and part of the sample was analyzed by infrared spectroscopy using a Harrick single reflectance attenuated total internal reflectance (ATR) accessory. The remainder of the sample was subjected to derivatisation into their methyl esters. The methyl esters of isomerized fatty acids were then analyzed by gas chromatography after appropriate dilution in heptane.

The results show that the thermally induced castor oil mainly gave CLA profiles containing isomers ranging from 7t9c to 12t14t while main isomers were the 9c11t, 10t12c and trans CLAs. Addition to CLAs considerable composition of 18:2 linoleic acid isomers (9t12t, 9c12t, 9t12c and 9c12c) were formed. Furthermore, the concentrations of the isomers were different in the samples depending on the duration of thermal induction and the temperature. It appears that [1, 3] and [1, 5] sigmatropic rearrangements and positional isomerization take place in heated mixtures in addition to dehydration.

Keywords: Castor oil, Conjugated Linoleic Acid, Dehydration, Infrared spectroscopy, Gas Chromatography
ICCBES-1105
Energy Efficiency Improvement of Integrated Biomass Gasification Fuel Cell Power System

Woranee Paengjuntueka, Jitti Mungkalasirib
a Chemical Engineering Department, Engineering Faculty, Thammasat University, Thailand
E-mail address: pworanee@engr.tu.ac.th

b MTEC, National Science and Technology Development Agency, Thailand
E-mail address: jitti.mungkalasiri@nstda.or.th

1. Introduction
Due to the urban spawn and population growth in Thailand, electricity is intermittent. Nowadays, many countries support and promote the development of more alternative energy to reduce dependence on petroleum products. Alternative energy sources are renewable, which means that no matter how much they are used, there will always be more energy available to use and also they have lower carbon emissions compared to conventional energy sources. Alternative energy comes in a number of different forms such as solar power, wind power, hydroelectric, biomass power and biogas power. Biomass is a renewable and sustainable source to produce environmentally friendly energy. Moreover, agricultural residues in Thailand such as rice straw, bagasse, palm empty bunch and cassava rhizome have increased in recent year. Biomass residues can also use for domestic heating and industrial cogeneration. In Thailand, rice straw is one of the main agricultural residues and it is estimated to be about 26 Mt/year [1]. For this reason, rice straw (biomass) is one of major sustainable solutions for further power generations designed for Thailand perspective.

2. Methods
Biomass gasification for power generation has received considerable attention as a partial substitute for fossil fuels power generation. Gasification is the incomplete combustion that converts a carbon-contain feedstock into syngas including hydrogen, methane, carbon monoxide, carbon dioxide, water and other gaseous hydrocarbons. To increase power efficiency, fuel cell is one of the most suitable ways to combine with biomass gasification especially solid oxide fuel cell (SOFC). SOFC is considered as the most encouraging fuel cell type due to its high power generation efficiency about 60% and long term stability. In order to use energy more efficiently, energy analysis should be evaluated. In this study, Aspen plus is used to perform an integrated biomass gasification fuel cell (BGFC) system with rice straw feedstock for power generation. The composition of rice straw and parameters for fuel cell simulation are referenced by [2]. In addition, the electrical output from fuel cell is predicted by electrochemical model [3].
3. Results and Conclusion

The simulated BGFC system is revealed in Fig.1. The results show that at the optimal operating condition of 205 kg rice straw/hr, 2.0 air-to-biomass ratio, 1.3 steam-to-biomass ratio, 1000°C of gasifier temperature, 1000°C of fuel cell temperature, 1 bar of gasifier pressure and 5 bar of fuel cell pressure, the electricity production is 1,396 kW with 73.89% energy efficiency. Nevertheless, the BGFC operation produces large quantities of waste heat and steam. Therefore, energy efficiency of the BGFC system can be improved by recovering the waste heat and unused steam in order to reduce the energy consumption in the system. In the BGFC system, unused steam from SOFC can be recycled to be a feedstock of steam turbine and waste heat from SOFC is able to use as a heat source for gasifier. The results revealed that the BGFC with heat recovery system can improve energy efficiency to 77.84% and electricity to 1,441 kW.

![Fig. 1: Simulated biomass gasification fuel cell (BGFC) system](image)

Keywords: Biomass gasification, Energy efficiency, Fuel cell, Power generation, Simulation

Acknowledgements

The authors would like to acknowledge the support from Engineering Faculty and Thammasat University Scholarships.

References


ICCBES-1244
Monitoring of D-Penicillamine in Aqueous Environmental Samples Based on Inhibitory Kinetic Method as an Analytical Tool

Surendra Prasad1, Masafumi Yoshida2
1 School of Biological and Chemical Sciences, Faculty of Science, Technology and Environment, The University of the South Pacific, Fiji
E. mail: prasad_su@usp.ac.fj

2Department of Natural Sciences, Faculty of Knowledge Engineering, Tokyo City University, Japan
E. mail: yoshida@miobox.jp

Recent years have seen an upsurge in the use of kinetics in analytical chemistry. During the past decade considerable efforts have been directed towards developing increasingly sensitive kinetic methods for the determination of trace environmental pollutants, species of biological, food and medicinal interest. The kinetic methods have been recognized as a valuable technique for trace analysis due to their high specificity, sensitivity and precision combined with simple photometric monitoring procedure and economy compared to the other methods of comparable analytical merits used for trace analysis.

Biologically active thiol i.e. D-penicillamine (D-PA) binds strongly with Hg(II) ion leading to the inhibition of the rate of Hg(II) catalyzed substitution of cyanide in potassium hexacyanoruthenate(II) (K4[Ru(CN)6]4-) by nitroso-R-salt (NRS). This forms the basis to develop an inhibitory kinetic method for the quantitative determination of this compound at micro molar levels. The reaction was followed spectrophotometrically at 525 nm (λmax of [Ru(CN)6NRS]3– complex) under optimized reaction conditions at 8.75 × 10⁻⁵ M [Ru(CN)6⁴⁻], 3.50 × 10⁻⁴ M [NRS], pH 7.00±0.02, ionic strength (µ) 0.1 M (KCl) and temperature 45.0±0.1°C. The modified mechanistic scheme is proposed to understand the inhibition caused by D-PA on Hg(II) catalyzed substitution of cyanide by NRS in [Ru(CN)6]⁴⁺. The detection limit was found to be 3.0 × 10⁻⁶ M.

While the principles have general validity, in this presentation, an attempt will be made to the discussion centered around the recent works done in our laboratory using inhibited ligand substitution reaction on hexacyanoruthenate(II).

Keywords: D-penicillamine, Inhibitory effect, Ligand substitution reaction, Potassium hexacyanoruthenate(II), Nitroso–R–salt.
Chemical Sciences (2)/ Industrial Engineering (2)/

Environmental Sciences (5)

Thursday, May 12, 2016 13:00-14:30 Room 1007

Session Chair: Prof. Chaoyuan Zhu

ICCBES-1239
α-Glucosidase Inhibitor from the Fruit of Helicteres Isora Linn
Wimolpun Rungprom | Phranakhon Si Ayutthaya Rajabhat University

ICCBES-1262
Molecular Absorption and Fluorescence Spectra in Solution Simulated by Damped Franck-Condon Factors
Chaoyuan Zhu | National Chaio-Tung University

ICCBES-1268
Toluene Destruction by Non-Thermal Plasma in Corona Discharge Reactor
Malee Santikunaporn | Thammasat University
Snunkhaem Echaroj | Thammasat University
Non Srisawaivilail | Thammasat University
Jantamanee Machachanon | Thammasat University
Channarong Asavatesanupap | Thammasat University

ICEAI-1035
A Feasible Approach to Camber Angle Measurement for Vehicle Wheel Alignment
Jieh-Shian Young | National Changhua University of Education
Chih-Yuan Chuang | National Changhua University of Education

ICEAI-1229
Analyzing Coastal Vulnerability Index Using Integrated Satellite Remote Sensing and Geographic Information System: A Case Study of Denpasar Coastal Zone
Bambang Semedi | University of Brawijaya
Badrul Huda Husain | University of Brawijaya
Nurin Hidayati | University of Brawijaya
ICEAI-1202
Phytoremediation of Lead (Pb) For Ecosystems Contaminated Sidoarjo Mud Volcano Using Cat Tail (Typha latifolia L.)
Tarzan Purnomo | Universitas Negeri Surabaya
Abstract
Diabetes is a metabolic disorder where the body fails to utilize the ingested glucose properly. Type 2 diabetes characterized by insulin resistance, which may be combined with relatively reduced insulin secretion. An effective strategy for Type 2 diabetes therapy is to suppress glucose level through inhibition of intestinal α-glucosidase. In our previous work, we succeeded in identifying several α-glucosidase inhibitors from medicinal plants which selected from screening result along with their traditional use as anti-diabetic remedies. In this paper, we expand this approach in search of α-glucosidase inhibitors from fruits of *Helicteres isora* Linn., the plant that used in traditional medicine to cure many diseases all over asian countries.

The fruit of *Helicteres isora* were extracted methanol with 50% methanol by soxhlet extractor and further partitioned with dichloromethane n-butanol and aqueous-soluble fractions, respectively. All extracts were evaporated and tested the α-glucosidase inhibitory activity. The n-butanol extract show the most potent inhibition. Bioassay-guided for fractionation of the most active fraction led to isolation of rosmarinic acid and theirs glucoside. The structure of isolated compounds were elucidated by spectroscopic experiments. All isolated compounds were tested α-glucosidase inhibitory activity including kinetic investigation.

Bioassay-guided fractionation of active fraction led to isolation of rosmarinic acid (1) 4′-O-β-D-glucopyranosyl rosmarinic (2) and 4,4′-O-di-β-D-glucopyranosyl rosmarinic (3) The isolated compounds inhibited maltase with IC<sub>50</sub> values in the range of 27.21-81.60 μM, which are equipotent to standard antidiabetic drug, acarbose. The kinetic of 4,4′-O-di-β-D-glucopyranosyl rosmarinic (3) indicated that inhibited maltase with mix-type inhibition.

**Keywords:** *Helicteres isora* Linn, α-glucosidase inhibitor, Diabetes, kinetic investigation

1. **Background/ Objectives and Goals**
Diabetes is a metabolic disorder where the body fails to utilize the ingested glucose properly. Type 2 diabetes characterized by insulin resistance, which may be combined with relatively reduced insulin secretion. An effective strategy for Type 2 diabetes therapy is to suppress glucose level through inhibition of intestinal α-glucosidase. In our previous work, we
succeeded in identifying several α-glucosidase inhibitors from medicinal plants which selected from screening result along with their traditional use as antidiabetic remedies. In this paper, we expand this approach in search of α-glucosidase inhibitors from fruits of *H. isora*.

*Helicteres isora* is belonging to Sterculiaceae family, it is sub-deciduous shrub or small tree, which is distributed throughout India and Southeast asia. The fruit of *H. isora* has long been used for treat several diseases as particularly as an infusion. The aforementioned traditional used as an antisplamodic, antipyretic, antidiarrhoic and diabetic remedies. Therefore, the identifying the active component in fruit of *H. isora*, putatively responsible for retarding α-glucosidase function is the aim of this investigation.

### 2. Methods

#### 2.1 Extract and Separation of

The fruit of *H. isora* (2 kg) collected from Ayutthaya province, was extracted with 50% MeOH by soxhlet (24 hr., 60°C). The solution of 50% MeOH extract were further partitioned with dichloromethane and n-butanol, successively. All fractions were concentrated by removing of each solvent under reduced pressure to yield the the dichloromethane extract (32.8), n-butanol extract (35.6 g) and water extract (40.2 g). α-glucosidase bioassay-guided for fractionated the most active fraction. The n-butanol extract is the most potent fraction were initially fractionated by vacuum column chromatography using dichloromethane and MeOH yielding five major fractions. The second fraction also showed the highest inhibitory against α-glucosidase and further purified Sephadex LH 20 (90:10 MeOH:CH₂Cl₂) and followed by HPLC (Reverse phase, ODS 1:4; 1:2 MeOH:H₂O) to furnish rosmarinic acid (1) 4′-O-β-D-glucopyranosyl rosmarinic (2) and 4,4′-O-di-β-D-glucopyranosyl rosmarinic (3)

#### 2.2 α-Glucosidase inhibition assay

Inhibitory effect against α-glucosidase from baker’s yeast was performed using our protocol previously reported. Briefly, the α-glucosidase (0.1 U/mL) and substrate (1 mM *p*-nitrophenyl-α-D-glucopyranoside) were dissolved in 0.1 M phosphate buffer, pH 6.9. A 10 μL of test compound (1 mg/mL in DMSO) was incubated with 40 μL of α-glucosidase at 37 °C for 10 min. A 50 μL substrate solution was then added to the reaction mixture and incubated at 37 °C for additional 20 min. After the reaction was terminated by adding 100 μL of 1 M Na₂CO₃. Enzymatic activity was quantified by measuring the absorbance at 405 nm (Bio-Rad microplate reader model 3550 UV). The percentage inhibition was calculated by \( \left[ \frac{(A₀-A₁)}{A₀} \right] \times 100 \), where A₀ is the absorbance without the sample, and A₁ is the absorbance with the sample. The IC₅₀ value was determined from a plot of percentage inhibition versus sample concentration. Acarbose was used as standard control and the experiment was performed in triplicate.
In addition, inhibitory activity against \( \alpha \)-glucosidase from rat intestine was determined using our developed method.\(^3,4\) The crude enzyme solution prepared from rat intestinal acetone powder was used as a source of maltase and sucrase. Rat intestinal acetone powder (1 g) was homogenized in 30 mL of 0.9\%NaCl solution. After centrifugation (12,000g \( \times \) 30 min), the aliquot was subjected to assay. A 10 \( \mu \)L of test compound was added with a substrate solution (10 mM maltose and 100 mM sucrose, each 20 \( \mu \)L), 0.1 M phosphate buffer (pH 6.9, 30 \( \mu \)L), glucose oxidase solution (80 \( \mu \)L) and enzyme solution (20 \( \mu \)L). The reaction mixture was incubated at 37 \( ^\circ \)C (10 min for maltase and 40 min for sucrase) and its absorbance was determined at 500 nm. Percentage inhibition and IC\(_{50}\) value was obtained using aforementioned methodology.

2.2 Kinetic study of \( \alpha \)-glucosidase inhibitory effect.\(^5\) The mechanism underlying inhibitory effect was investigated by analyzing enzyme kinetic data using the above reaction. Maltase activity was maintained at 0.45 U/mg protein in the presence of quercetin (from 0.1–1.0 mg/mL) at various concentrations of maltose (2, 6, 10, 16, 20 mM). A series of \( V_{\text{max}} \) and \( K_m \) values were obtained from Y intercepts and calculated by slope \( \times \) \( V_{\text{max}} \), respectively. A similar method was also applied for sucrase, in which its activity was kept at 0.07 U/mg protein.

3. Results
The isolated compounds from were isolated using \( \alpha \)-glucosidase assay guided were identified as rosmarinic acid (1) 4'-\( O-\beta \)-D-glucopyranosyl rosmarinic (2) and 4,4'-\( O \)-di-\( \beta \)-D-glucopyranosyl rosmarinic (3) by spectroscopic analysis particularly NMR and MS which well coincided well with previous report.\(^2\)

![Structure of isolate compound from H. isora](image)

compound 1 2 and 3 were tested for inhibitory effect against \( \alpha \)-glucosidases from two different sources, baker’s yeast and rat intestine. Apparently, they selectively inhibited rat intestinal maltase and sucrase whereas inhibitory activity against baker’s yeast \( \alpha \)-glucosidase was not observed (Table 1)
Compounds 2 and 3 were classified as glucoside of rosmarinic acid, both of them showed different number of glucose. They have one and two glucose groups, respectively while 1 have no glucose core. Compound 1, 2 and 3 showed selectively inhibitory effect against α-glucosidase from rat intestine. Compound 3 was much more active than compound 1 and 2 with IC_{50} value of 27.21 for maltase. It was indicated that increasing number of glucose units in the molecule led to increase inhibitory activity in rat intestine (maltase and sucrase).

The kinetic assay was performed using Lineweaver-Burk plots. The inhibitory activity of compound 3 against the intestinal maltase was carried out. The Lineweaver-Burk plots of the initial velocity versus enzyme concentrations in the presence of different concentrations of compound 3 gave a series of straight lines; all of which intersect to the second quadrant (Fig 2). The analysis demonstrated that V_{max} decreased with elevated K_{m} in the presence of increasing concentrations of compound 3. This behavior indicated that compound 3 inhibited maltase by two distinct way; forming competitively enzyme inhibitor (EI) complex and interrupting enzyme-substrate (ES) intermediate through forming enzyme-substrate-inhibitor (ESI) intermediate complex in noncompetitive manner.

To elucidate binding affinities of EI and ESI complexes, a Dixon plot and secondary report were performed, respectively. The Dixon plot (Fig 3a) of slope of lines in Lineweaver-Burk relation versus the inhibition concentration produced EI dissociation constant (K_{i}) of 4.97 μM, whereas the secondary replot (Fig 3b) of intercept versus inhibitor concentration generated ESI dissociation constant (K'_{i}) of 16.01 μM. The putative binding mode of was rationalized that one inhibitor can bind either to active site of free maltase or to maltase-maltose intermediate. The

| compounds | baker’s yeast | rat intestinal | | | |
| --- | --- | --- | --- | --- |
| | | maltase | Sucrase | |
| 1 | NI a | 81.60 | 115.23 | |
| 2 | 96.32 | 66.40 | NI a | |
| 3 | NI a | 27.21 | NI a | |
| Acarbose | 211.55 | 64.67 | 57.80 | |

*aNo inhibition, inhibitory effect less than 30% at 10 mg/mL.
3.22 times greater values of $K_i$ suggested a weaker binding of compound 3 to maltase-maltose intermediate and indicated that inhibition mechanism is competitive predominant over noncompetitive. Notably, compound 3 demonstrates inhibitory effect against intestinal maltase with mixed-type inhibition. (Table 2)

![Lineweaver-Burk plot for inhibitory activity of 3 against maltase.](image1)

**Fig.1** : Lineweaver-Burk plot for inhibitory activity of 3 against maltase.

![Secondary plot of slope [I] deduction of $K_i$ of 3 against maltase.](image2)

**Fig 2.** Secondary plot of slope [I] deduction of $K_i$ of 3 against maltase.
In summary, we have succeed in first identifying compound 3 as a putative hypoglycemic agent in *H. isora* through inhibiting intestinal maltase. A mix-type inhibition mechanism indicated that compound 3 can retard enzyme function by not only direct binding to maltase but also interfering maltase - maltose intermediate. Therefore, compound 3 also inhibit maltase by competitive manners. The rosmarinic 1 and its glucoside 2,3 possibly attenuated blood glucose level through inhibiting maltase function. The increasing number of glucose units highly improved inhibitory effect of compound 3 over 2 and 1. The mechanism underlying inhibition of discovered in our investigation suggested a possible guidance for the use of *H. isora* fruit as an alternative drug or as combination with currently used for diabetes treatment.

3.3 Acknowledgments

This research was supported by the CHE -IG grant from Commission of Higher Education—and ARU research fund (ARU-RF -2556)

4. References


ICCBES-1262
Molecular Absorption and Fluorescence Spectra in Solution Simulated by Damped Franck-Condon Factors

Chaoyuan Zhu
Department of Applied Chemistry, National Chiao-Tung University, Taiwan
E-mail address: cyzhu@mail.nctu.edu.tw

Abstract
Franck-Condon factors bridge the gap between theoretical modeling and experimental observations for molecular electronic spectroscopy and electron transfer. Under the displaced harmonic oscillator approximation, multidimensional Franck-Condon factors are decomposed into a product of many one-dimensional (1D) Franck-Condon (FC) factors, which are successfully applied to simulate molecular vibronic spectra in gases phase. For dealing with simulation of the spectra in solution, various ab. initio methods, such as polarizable continuum model (PCM) and explicit solvent model, added correction in static interactions between solute and solvent molecules. However, how to treat dynamic correction to the spectra is not well-studied. We have recently developed the dynamic correction method leading to direct modification of Franck-Condon factors by damped oscillators. This method was applied to simulate absorption and fluorescence spectra of perylene, rubrene molecule in benzene and cyclohexane solutions. The present simulation presents nice physical insights for dynamic correction to solvent-enhanced vibronic spectra.

Figure 1. Perylene and rubrene vibronic spectra in benzene and cyclohexane solutions.

Keyword(s): Absorption, Fluorescence Spectra, Franck-Condon Factor, Solvent effect.
References


ICCBES-1268

Toluene Destruction by Non-Thermal Plasma in Corona Discharge Reactor

Channarong Asavatesanupap\textsuperscript{a}, Non Srisawaivilai\textsuperscript{b}, Jantamanee Machachanon\textsuperscript{b}, Snunkhaem Echaroj\textsuperscript{b}, Malee Snuntikunaporn\textsuperscript{b,*}

\textsuperscript{a}Department of Mechanical Engineering, Faculty of Engineering, Thammasat University, Thailand

\textsuperscript{b}Department of Chemical Engineering, Faculty of Engineering, Thammasat University, Thailand

E-mail: smalee@engr.tu.ac.th

Abstract

The decomposition of toluene in air by non-thermal plasma was investigated with a pin-to-plate corona discharge reactor at atmospheric pressure. The effects of applied voltage and flow rate of air on the toluene removal efficiency (TRE \%) and CO\textsubscript{2} selectivity (\%) were examined in absence of a catalyst. Data obtained after 60 minutes of operation showed an increase in specific energy density (SED) from 2.8 to 9.7 kJ/L was found to raise TRE of the system from 37\% to 44\%. However, if the SED is increased further to 22.7 kJ/L then coke accumulation was observed on the electrode plate which results in a reduction in TRE. Flow rate of air was found to have a negative impact on TRE due to shorter retention time. CO\textsubscript{2} selectivity was found to vary proportionally with TRE. Non-thermal plasma in corona discharge reactor was found to be a promising candidate for inexpensive but effective means of toluene destruction.

Keywords: Toluene, plasma, corona discharge

1. Introduction

Toluene molecule, categorized as one of the volatile organic compounds (VOCs), has been intensively employed as solvent for manufacture of paint, additive for gasoline fuel, adhesive and explosives. Due to its high volatility properties, acute and chronic inhalation exposure to toluene vapor may damage our kidney, liver and the central nervous system. Consequently, concentration of toluene vapour in workplace’s atmosphere was strictly regulated by health institutions [1,2]. For instance, the Occupational Safety Hazard Administration Permissible Exposure Limit (OSHA PEL) required that toluene concentration cannot exceed 300 ppm at any giving time [3]. The conventional methods for decomposition of VOCs include adsorption, catalytic oxidation, combustion and membrane separation. However, these methods are usually expensive and consumed large amount of energy. Moreover, the adsorption method is restricted due blockage of absorbents during operation.
Non-thermal plasma (NTP) is an advanced technology used for a variety of processes, such as alcohol/glycerol reforming for H$_2$ production [4-8] and ethylene epoxidation [9, 10]. Recently, NTP method has been introduced as a high performance and inexpensive means for VOCs abatement. This technology is based on oxidation reaction of VOCs compound under the presence of ionized charges. These ionized charges are considered as the fourth state of matter and they are created when atoms in gas are passed through the amplified electric current (electric arc) generated between two electrodes [4, 11, 12].

Utilization of the NTP technology for the destruction of toluene has been recently reported. The mechanism for toluene destruction under plasma influences consisted of the ionization of toluene, ion collisions and decomposition of the remaining compound into CO$_2$ and water by oxygen radicals and ionized charge. Therefore, an increase in selectivity toward CO$_2$ indicated a more complete destruction of toluene, hence an increase in toluene removal efficiency [13]. By products generated due to incomplete decomposition of toluene consisted of acetic acid, formic acid and benzene as shown in figure 1.

![Fig. 1: Mechanism of toluene destruction via NTP under oxygen atmosphere](image)

Different type of catalysts has been employed to assist with the decomposition of toluene molecules. These catalysts are usually categorized in term of their position relative to the plasma zone. For instance, in-plasma catalysts are placed inside the plasma zone and usually have high affinity toward hydrocarbon molecules. Therefore, when toluene vapor enter the
plasma zone they will be adsorbed onto the surface of these catalysts, which help increase the chance of collision between ionized charge and toluene molecules. In-plasma catalysts that have been studied included ferro-electrics material [14, 15], humidity-resisted NiO/TiO2/SiO2 [16], TiO2/γ-Al2O3/nickel foam [13], 1wt% Au/Al2O3 [17], Nb2O5 [17], and NiO/TiO2 [18]. It was reported that under the presence of TiO2 coated on γ-Al2O3 catalyst and flow of air, conversion of toluene can reach as high as 80% [19]. Apart from TiO2 coated materials, recent research have shown that FeOx can also assist the destruction of toluene through the NTP method as well. Meijuan Lu et al. reported a dramatic increase in O2 adsorption on FeOx coated SBA-15 compared to plain SBA-15. Consequently, an increase in the availability of O2 on catalyst’s surface causes the toluene removal efficiency to increase as well [20]. Impregnation of 1% Ag and 5% Mn on SBA-15 (AgMn/SBA-15) had been found to result in higher toluene conversion compared to plain SBA-15 and SBA-15 loaded with either Ag or Mn metal. Formation of coke deposit on catalyst was also found to be lower for SBA-15 loaded with the two metals. Temperature-program reduction (TPR) revealed that Mn is reduced at 300°C, but Ag cannot be reduced. However, additional of Ag metals was found to improve catalytic activity because they increase dispersity of Mn metals on the catalytic surface [1].

The second type of catalysts for NTP reaction is post-plasma catalysts, such as Mn/carbon [21], 3%FeOx/SBA-15 [20] and CuOMnO2/TiO2 [22]. Under the presence of air, plasma will convert oxygen to ozone. Post-plasma catalyst are located after the plasma zone inorder to adsorb these ozone molecules. Toluene molecule then reacts with the adsorbed ozone on the post-catalyst’s surface and decomposed into CO2 and water. So far most of the researches have been conducted using a dielectric barrier discharge reactor (DBD) under the presence of a catalyst. To the best of our knowledge, up to now, there are few reports on the destruction of toluene using the pin-to-plate corona discharge reactor without the additional support from a catalyst.

The present study aimed to study decomposition of toluene vapor inside the novel pin-to-plate corona discharge reactor. The non-thermal plasma technology will be evaluated without the use of any catalyst. The influence of applied voltage and flow rate of air on toluene removal efficiency (TRE) and CO2 selectivity will be reported.

2. Experimental
Figure 2 illustrates diagram of the experimental setup consisting of a pin-to-plate corona discharge reactor, a high voltage transformer (Henry), a digital oscilloscope (GDS-820C), pulse generator, power amplifier (ESTEL, EX230AL5N) and power analyzer (Lutron, DW-6090). The reactor was a 21 cm long quartz tube (0.9 cm outer diameter) consisting of two metal electrode rods. The first electrode rod (a normal metal rod) referred to as a pin was placed through the top of the reactor while the second electrode rod (metal rod with a small
plate at the end) was positioned through the bottom of the reactor. The ends of the two electrodes were adjusted to approximately 1 cm apart.

Each experiment was carried out at atmospheric pressure, temperature of 190°C and frequency of 300 Hz. The applied voltage was adjusted so that the specific density, as calculated by equation 1, ranged from 2.7 to 22.5 kJ/L using the pulse generator. A syringe pump was used to deliver toluene (99.5%, QREC Co., Ltd) at 0.15 mL/h into the mixing chamber which was heated at 140°C. At this temperature toluene is converted to vapor phase having a concentration of 50 ppm. Air zero (Praxair Co., Ltd) was flowed into the mixing chamber and passed through the reactor at the rate of 40 to 60 mL/min. The effluent from the reactor was analyzed 20, 40 and 60 minutes after operation by an on-line HP 5890 series II gas chromatography equipped with a flame ionization detector. Area under the GC curves were calibrated and was used to calculate toluene removal efficiency (TRE) and CO₂ selectivity (S_{CO₂}) as shown in equation 2 and equation 3.

\[
S_{ED}(J/L) = \frac{P}{F_{air}} \times 60 \quad (1)
\]

\[
TRE(\%) = \frac{C_{T,in} - C_{T,out}}{C_{T,in}} \times 100 \quad (2)
\]

\[
S_{CO₂}(\%) = \frac{C_{CO₂}}{7(C_{T,in} - C_{T,out})} \times 100 \quad (3)
\]

where \(C_T\) is the concentration of toluene in ppm, \(C_{CO₂}\) is the concentration of CO₂ in ppm, \(P\) is discharge power in watt and \(F_{air}\) is the flow rate of air in mL/min.


3. Results and discussion

3.1 Effect of specific energy density (SED)
Figure 3 exhibited the relationship between specific energy density and the toluene removal efficiency from effluent gas analyzed 40 and 60 minutes after the start of the operation. For the effluent gas analysed 40 minutes after operation, it was found that toluene removal efficiency increase from 15% to 23% as specific energy density increase from 2.7 to 9.6 kJ/L. Similarly, analysis of the effluent gas 60 minutes after operation showed an increase in toluene removal efficiency from 37% to 44% as well. However, a further increase in specific energy density to 22.5 kJ/L resulted in a slightly reduction in toluene removal efficiency for effluent gas analyzed at both 40 and 60 minutes after operation. This is because at higher specific energy density more coke is formed on the pin and plate of the plasma reactor, which reduces the intensity of the electric arc.

Selectivity to CO$_2$ is also a good indicator of the degree of completeness in the destruction of toluene. According to the data from effluent gas collected 40 minutes after operation, an increase in specific energy density was found to increase CO$_2$ selectivity from approximately 0.2% to 1.6% as shown in figure 4. However, when the specific energy density increase to 22.5 kJ/L, it was shown from data collected 40 minutes after operation that CO$_2$ selectivity decreased slightly. Analysis of effluent gas 60 minutes after operation reveal a reduction from CO$_2$ selectivity from 5.6% to 5% when specific energy density increased to 22.7 kJ/L. A reduction in both toluene removal efficiency and CO$_2$ selectivity when the specific energy density reaches 22.5 kJ/L is caused by accumulation of coke on the plate of the electrode. This layer of coke deposit will prevent the electric arc from operating at full capacity. Selectivity to CO$_2$ corresponded well with the toluene removal efficiency. Other researches also pointed out how selectivity to CO$_2$ changes proportionally with toluene removal efficiency [2, 3, 16, 18, 23].
3.2 Effect of air flow rate

Figure 5 illustrated the effect of air flow rate on toluene removal efficiency and CO$_2$ selectivity. It can be observed that toluene removal efficiency and CO$_2$ selectivity decrease with increasing flow rate of air.

An increase of air flow rate from 40 mL/min to 60 mL/min cause toluene removal efficient to decrease from 50.5% to 35.1% and the CO$_2$ selectivity to decrease from 6.4% to 4.5%. This is because an increase in air flow rate decreases the residence time of toluene molecule inside the plasma zone.
4. Conclusion

With the use of pin-to-plate corona discharge reactor for hosting plasma charges, this research successfully decompose toluene with a removal efficiency of 50% under the specific energy density of 9.6 kJ/L with the use of a catalyst. However, an increase in specific energy density to 22.6 kJ/l was to found cause coke deposition on the plate of the electrode, which causes a clear reduction in the toluene removal efficiency. CO₂ selectivity was found to vary proportionally with toluene removal efficiency. Toluene removal rate was found to decrease with air flow rate. In conclusion, it is clearly shown that non-thermal plasma has a potential of coming the new method for decomposition of toluene. Improvement of toluene removal efficiency can be accomplished by utilization of either in-plasma or post-plasma.

5. Reference

ICEAI-1035
A Feasible Approach to Camber Angle Measurement for Vehicle Wheel Alignment

Jieh-Shian Young*a, Chih-Yuan Chuangb

aInstitute of Vehicle Engineering, National Changhua University of Education, Taiwan
E-mail address: jsyoung@cc.ncue.edu.tw

bInstitute of Vehicle Engineering, National Changhua University of Education, Taiwan
E-mail address: nike81929@yahoo.com.tw

Abstract
This study aims at the camber angle measurement for the vehicle wheel alignment. Instead of
the current commercial approaches which apply the computation vision techniques, the
proposed approach can be achieved by the 3-axis accelerometer. The coordinate transformation
from a vehicle coordinate to the camber angle sensor coordinate is indispensable. Furthermore,
the x-axes of the sensor and the vehicle need not be perfectly aligned since the proposed
approach can evaluate the wheel camber angle directly from accelerometer. This approach can
also be realized by micro control unit (MCU). The value of the measured camber angle will be
acquired by the bluetooth equipped device. The result shows that this approach is not only
feasible but realizable.

Keywords: Accelerometer, camber angle, coordinate transformation, wheel alignment.

1. Introduction
The safety and quality of vehicles are always crucial to research, development, and
manufacture in the automotive industry. Vehicle wheel alignment including inspection and
adjustment of the wheel characteristic angles becomes essential (Díaz, Ramírez, & Muñoz,
2004) since wheel camber angle affects steering controllability and stability while the wheel
toe angle is related to fuel efficiency, tire lifespan, and driving comfort (Knowles, 2007).

Misalignments of the wheel characteristic angles may cause rapid and irregular tire wear. In
addition, they may diminish the capability of the vehicle safety and handling. The camber
angle defined as the angle between the vertical axis of wheel and that of the vehicle viewed
from the front or rear has the major influence both on the cornering force and on the road
handling of the vehicle (Furukawa, Yuhara, Sano, Takeda, & Matsushita, 1989). That is the
camber angle plays one of the most significant roles in vehicle safety and handling.
The technique development for the camber angle measurement has received a great attention and experienced a tremendous improvement. In short, the measurement methods moved from mechanical and electromechanical measurement devices to vision-based systems (2D and 3D). The former was labor-intensity and time-consuming. Besides, the accuracy of the measurement was also a gross problem. The later has improved the accuracy of the measurement from the former. Nevertheless, the target boards have to be mounted on the wheels before applying the later method as the vehicle steadies on the platform (Li, Gao, & Zhang, 2011; Wang & Tu, 2007). Then, the vehicle should move on the platform for a distance while the video cameras start to measure. Figure 1 shows the typical computer vision-based inspection systems for wheel alignment. This method also has some drawbacks. For instance, mounting the targets on wheels takes more time required for measurement since the mounting procedure has to pay more attention with extremely stable connections to gain more accurate results during movements and rotations of wheels. Besides, moving the vehicle on the platform will tend to hazardous conditions. Furferi et al have proposed a method to design and assess a machine vision-based system for contactless measurement of vehicle wheel alignment (Furferi, Governi, Volpe, & Carfagni, 2013). This method can provide the camber angle without highly precise application of structured targets on the wheels. Padegaonkar et al also addressed an idea that implements a contactless measurement of wheel characteristic angles using 3D stereo-vision technique in order to overcome the above mentioned drawbacks (Padegaonkar, Brahme, Bangale, & Raj, 2014). Baek et al have utilized point clouds from the range image stream generated by Microsoft Kinect system which is equipped with a consumer-grade depth-sensing camera (Baek, Cho, & Bang, 2014).

In this paper, a feasible approach to measure the camber angle is proposed. The coordinate transformation from a vehicle coordinate to the sensor coordinate is derived to measure the camber angle. The proposed approach employs the micro control unit to achieve the camber angle measurement. The x-axis of the camber angle sensor need not be exactly aligned to that of the wheel. That will save the process time and make the measurement applicable since the
experienced mounting skill of the sensor is not necessary. It shows that this approach is not only feasible but realizable by using the 3-axis accelerometer to measure the camber angle. Furthermore, the measurement accuracy does not degrade as using an appropriate accelerometer.

For convenience, this paper defines the 3-D components in a Cartesian coordinate \(C\) as follows.

\[
\begin{pmatrix}
  x_c \\
  y_c \\
  z_c
\end{pmatrix}_C = x_c\vec{i}_C + y_c\vec{j}_C + z_c\vec{k}_C,
\]

or

\[
\begin{pmatrix}
  x_c \\
  y_c \\
  z_c
\end{pmatrix}_C = \begin{bmatrix}
  \vec{i}_C & \vec{j}_C & \vec{k}_C
\end{bmatrix} \begin{bmatrix}
  x_c \\
  y_c \\
  z_c
\end{bmatrix},
\]

where \(\vec{i}_C, \vec{j}_C, \vec{k}_C\) are the unit vectors of \(x, y, \) and \(z\)-axes for coordinate \(C\), respectively. That is \((x_c \quad y_c \quad z_c)^T_C\) denotes the vector in coordinate \(C\) and \([x_c \quad y_c \quad z_c]^T\) denotes the 3-by-1 matrix according with the vector \((x_c \quad y_c \quad z_c)^T_C\).

### 2. The Coordinate Transformation between Camber Angle Sensor and Vehicle

Figure 2 shows the vehicle coordinate \((V)\) while \(x\)-axis, \(y\)-axis and \(z\)-axis of vehicle coordinate are forward, rightward, and downward, respectively. \(x, y, \) and \(z\)-axes of the sensor coordinate \((S)\) defined as \(x_s, y_s, \) and \(z_s\) aligned with the sensor show in Figure 3. The Euler angles between coordinate \(V\) and \(S\) including yaw and pitch angles are necessary in camber angle measurement. The camber angle is indeed the pitch angle, \(\theta\). In addition, the yaw angle, \(\psi\), is the misaligned angle between \(x\)-axes of the sensor coordinate and the vehicle coordinate. The pitch angle and the yaw angle are rotated by \(x\)-axis of coordinate \(V\) and by \(y\)-axis of coordinate \(S\), respectively, as shown in Figures 2 and 3 for two different coordinates \(V\) and \(S\). According to the definition of the coordinates in Figure 2,

\[
\begin{bmatrix}
  x_w \\
  y_w \\
  z_w
\end{bmatrix} = \begin{bmatrix}
  1 & 0 & 0 \\
  0 & \cos \theta & -\sin \theta \\
  0 & \sin \theta & \cos \theta
\end{bmatrix} \begin{bmatrix}
  x_p \\
  y_p \\
  z_p
\end{bmatrix},
\]  

\(1\)

where \(\theta\) is the camber angle from the coordinate \(S\) to the coordinate \(W\) and

From definition in Figure 3,

\[
\begin{bmatrix}
  x_w \\
  y_w \\
  z_w
\end{bmatrix} = \begin{bmatrix}
  \cos \psi & 0 & \sin \psi \\
  0 & 1 & 0 \\
  -\sin \psi & 0 & \cos \psi
\end{bmatrix} \begin{bmatrix}
  x_s \\
  y_s \\
  z_s
\end{bmatrix},
\]  

\(2\)
Substituting (2) into (1), it yields
\[
\begin{bmatrix}
x_r \\
y_r \\
z_r
\end{bmatrix} = \begin{bmatrix}
\cos \psi & 0 & \sin \psi \\
\sin \theta \sin \psi & \cos \theta & -\sin \theta \cos \psi \\
-\cos \theta \sin \psi & \sin \theta & \cos \theta \cos \psi
\end{bmatrix} \begin{bmatrix}
x_s \\
y_s \\
z_s
\end{bmatrix}.
\] (3)

Figure 2. Front view of vehicle and wheel coordinates with pitch angle.

Figure 3. Side view of wheel and sensor coordinates with yaw angle.

3. Approach to Camber Angle Measurement

The acceleration is only the gravity along \(z\)-axis of coordinate \(V\) when the vehicle is steady on the horizontal platform for the camber angle measurement, i.e., \(\ddot{a} = g \hat{k}_V\). In addition, the 3-axis accelerometer can sense the acceleration \(\ddot{a} = a_x \hat{i}_S + a_y \hat{j}_S + a_z \hat{k}_S\) where \(a_x\), \(a_y\), and \(a_z\) are the accelerations of the components in the \(x\), \(y\), and \(z\) axes in coordinate \(S\), respectively. In this case, (3) becomes
or
\[
\psi = - \tan^{-1} \frac{a_x}{a_z},
\]
and
\[
\theta = \tan^{-1} \frac{a_y}{a_z \cos \psi - a_x \sin \psi}.
\]
i.e.,
\[
\theta = \tan^{-1} \frac{a_y}{\sqrt{a_x^2 + a_z^2}}.
\]

The camber angle, \( \theta \), can be directly evaluated from (5) whether the x-axes of the sensor and the vehicle are aligned perfectly in the same direction or not. (5) will make the technicians easy to operate the camber angle measurement processes. However, in application, this study suggests that the \( x \)-axis of coordinate \( S \) may close to that of coordinate \( V \) due to the computation accuracy from MCU even though the perfect alignment is not necessary in (5).

Figure 4 shows a test result of the camber angle inspection system by the proposed approach implemented by MCU. The camber angle measured can be transmitted via the Bluetooth or other wireless components. In addition, the accuracy of this approach highly depends on that of the accelerometer. In this study, it is sufficient with less than 0.05\(^\circ\) accelerator sensitivity.
The magnitude of the acceleration sensed from the camber angle sensor is the same as the local gravity, i.e.,
\[ a_x^2 + a_y^2 + a_z^2 = g^2, \]  
(6)

then (5) becomes.
\[ \theta = \tan^{-1} \frac{a_y}{\sqrt{g^2 - a_z^2}}. \]

(7)

However, \( g \) is not always the same at different places. The proposed approach suggests (5) is better than (7) in calculating camber angle from MCU since \( g \) has to be evaluated from (6) always.

4. Conclusion

This paper has proposed a feasible approach to the camber angle measurement for the vehicle wheel alignment. The exact alignment of \( x \)-axes between coordinate \( S \) and coordinate \( V \) is not necessary since the proposed approach has considered the misaligned angle between them. This approach can directly inspect the camber angle in (5) with the accelerations for the 3 axes of coordinate \( S \). It is not only feasible but realizable. It can be also implemented by MCU. Furthermore, the data of the camber angle can be transmitted via the medium such as RS232, Bluetooth, wifi, etc.

The accuracy is one of the most significant issues. The accuracy analysis for different attitudes of the camber angle measured sensor is necessary. Besides, the calibration of the camber angle measured sensor is also essential since the 3-axis accelerometers cannot be installed in exact positions always as manufacturing. The misalignment of the accelerometer will contaminate the accuracy. The future study will include the accuracy analysis of the proposed approach for camber angle measurement and the calibration of the accelerometer.

5. References


ICEAI-1229
Analyzing Coastal Vulnerability Index Using Integrated Satellite Remote Sensing and Geographic Information System: A Case Study of Denpasar Coastal Zone

Bambang Semedi¹, Badrul Huda Husain¹*, Nurin Hidayati¹
Faculty of Fishery and Marine Sciences, University of Brawijaya, Malang, East Java Indonesia
Email adress: bambangsemedi@ub.ac.id

Abstract
The purpose of this study was to determine the physical coastal vulnerability index using satellite imagery and Geographic Information System (GIS) in coastal areas of Denpasar, Bali, Indonesia. Such information is very important in order to anticipate and reduce the impact of the environmental degradation and to use as a reference in determining the areas that are vulnerable and not vulnerable to natural physical factors. The data sources were satellite imagery of Landsat 8, Aster GDEM satellite imagery, TOPEX-Poseidon-Jason I-Jason II satellite imagery, tide data, and the wave height data. The method used in this study was weighting each parameter to determine how much impact was generated by oceanographic factors such as wave. The data were processed using spatial analysis of GIS. The buffer study area was about 1 kilometer to the sea and 1 kilometer towards the land. The results of this study indicated that the level of vulnerability of the coastal city of Denpasar was divided into 5 categories, namely: highly invulnerable, covering an area of ±728,041 m² (3.18 %), the category of invulnerable, covering an area of ± 5,813,509 m² (25.41 %), category medium, covering an area of ± 2,515,037 m² (10.99 %), category vulnerable, covering an area of ± 11,842,907 m² (51.78 %), and the class of highly vulnerable, covering an area of ± 1,971,119 m² (8.61 %) of the total of coastal area.

Keywords: Vulnerability, Coastal Zone, Satellite Remote Sensing, GIS, Denpasar.

Introduction
The beach is part of the coastal region that is most dynamic; meaning the beach area (the shape and location) change rapidly in response to natural processes and human activities. Utilization of beaches as residential areas is vitally important, with 70% of coastal areas around the world being areas of urban growth. Besides, the beach also has a very large potential damage if affected by a disaster or natural activities such as currents, waves and tsunamis.

*Corresponding Author:Bambang Semedi, Faculty of Fishery and Marine Sciences, University of Brawijaya, Malang, East Java of Indonesia. Email: bambangsemedi@ub.ac.id;
The development of science and technology has led to intense exploitation of natural resources in coastal areas with the carrying capacity of the beach in decline. Over the last few decades it is known that erosion has caused setbacks to the shoreline in various coastal regions that threaten the lives and livelihoods of coastal communities in Indonesia. Factors studied in this research are the natural physical factors caused by: changes in the shoreline, beach geomorphology, wave height, sea level rise, elevation, and tidal range.

The city of Denpasar is located in a coastal region of the most densely populated province of Bali. Around 78% of the coastal area of Denpasar serves as a hospitality area, 10% of coastal areas are used as rice fields and 2% of coastal areas are used as ports and highways. These uses may cause changes in the shoreline and physical damage to the coastal areas. Such changes will have an impact on coastal areas and put pressure on the carrying capacity of the coast that will disrupt and reduce the function of the beach. High coastal dynamics will carry implications and also threaten the survival of life as well as coastal development, especially the development of coastal cities.

The purpose of this study is to determine the physical coastal vulnerability index using satellite imagery and GIS in coastal areas of Denpasar, Bali, Indonesia. Such information is indispensable in order to anticipate and reduce the impact of environmental degradation and to be used as a reference in determining the vulnerable areas and invulnerable areas to natural physical factors.

**Materials and Methods**

The tools used in this study are as follows:

- GPS
- Digital Camera
- Software processing: Er-Mapper, Arc GIS v9.3.

Materials used in this study are:

- Landsat satellite imagery (Landsat 8 ; 2015)
- Aster satellite imagery (GDEM ; 2015)
- Tidal range data (2005-2015)
- Wave height data (2013-2014)

The method used in this research is weighting each parameter to determine how much impact is generated by oceanographic factors. Then, the data was processed using spatial analysis with a weighted overlay feature from the results of the weighting to each parameter and integrated into a geographic information system where the buffer area was about 1 kilometer to the sea.
and 1 kilometer towards the land. The data, including tidal range and wave-height data respectively, were obtained from the Geospatial Information Agency (BIG) and the Meteorological Climatology and Geophysics Agency (BMKG); elevation data (height level of mainland) was obtained from Aster satellite imagery GDEM 2015, the shoreline changes data were obtained from Landsat TM 2002 and Landsat 8 OLI 2015 satellite imagery. Spatial data (satellite imagery) was processed using software Er-Mapper V 7.1 with the procedure:

- Stacking Layer (stacking layer of satellite imagery band). This layer stacking process receipts 3 bands (4, 2, 5) for data processing shoreline change. Band combination used is a combination of band 2, 4 and 5, because these band are suitable combination to distinguish between land and sea. So that it can be recognized if there is a line has changed because of accretion or sedimentation. In addition, this layer stacking process also uses five bands, namely bands 1, 2, 3, 4 and 5 which are intended for data processing geomorphology of the coast. Each band is placed on one layer, followed by classification.
- Cropping the image aims to cut the satellite imagery in the research area.
- Masking Image. This process aims to be able to distinguish between the oceans and land by entering an algorithm into the formula editor if (i1 / i2) > 1 then 1 else if (i3 / i2) > 1 then 1 else 2.
- Unsupervised Classification. This classification is used to classify images based on common values in every pixel. This classification is done to determine the suitable ground check area.
- Supervised classification. This classification is used to classify the geomorphology class combined with GPS Track. This process is performed after the Ground Check.

Spatial data (satellite imagery) processed using Arc-GIS software V 9.3 with the procedure:

- Layouting and weighting Landsat 8 OLI 2015 satellite imagery Landsat 8 OLI 2015 for Geomorphology parameters
- Layouting, overlay, weighting Landsat TM satellite imagery and Landsat 8 OLI for shoreline change parameters and calculated using the EPR method
- Layouting, and weighting of Aster satellite imagery GDEM 2015 for the elevation parameter

Non-spatial data is processed using software Ms.Excel with the procedure:
- Inputing whole data into Ms.Excel for further processing (tidal range and wave height data)
- Data Sorting. The process of sorting H1 / 100 sorted from largest to smallest value for the wave height parameter
- Data Filter. The process of selecting the data in the form of 1/3 the amount of data on the amount of data H 1/100 to find the average significant wave height (Hs)
- Tidal Range Calculation

Variables and indicators used in coastal vulnerability assessment are as follows:
- Coastal Geomorphology: the indicator is a landform that identifies the resistance of a section of the beach erosion and accretion due to sea level rise
- Elevation (m): the indicator is the low areas related to the weakness of a beach by the danger of flooding and forward or retreat speed of the shoreline.
- The rate of shoreline change (m / year): the indicator is the presence of coastal erosion or accretion that identifies how quickly a section of the shoreline has suffered erosion or accretion
- Average tidal range (m): the indicator is the tidal differences that contribute to the danger of flooding the coast, where a large tidal range area will be more vulnerable than a small tidal range area
- Significant wave height (m): the indicator is the higher waves will increasingly affect the shoreline change and geomorphological conditions of the area
- Sea-level Rise (mm / year): the indicator is the higher sea level rise will increasingly affect the inundation that is generated

Weighting and scoring
The weights given to each parameter using a weighting according to Duriyapong (2011), while rank of vulnerabilities according to United States Geological Survey (1999).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weight (Xn)</th>
<th>Vulnerability Values (Wn)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Highly Invulnerable (1)</td>
</tr>
<tr>
<td>Shoreline Change (m/yr)</td>
<td>0.25</td>
<td>&gt; 2.0</td>
</tr>
<tr>
<td>Elevation (m)</td>
<td>0.35</td>
<td>≥ 30.1</td>
</tr>
<tr>
<td>Wave Height (m)</td>
<td>0.29</td>
<td>&lt; 0.5</td>
</tr>
<tr>
<td>Tidal Range (m)</td>
<td>0.11</td>
<td>&lt; 0.5</td>
</tr>
</tbody>
</table>
Shoreline Changes

Results of shoreline change analysis using Landsat TM 2002 and Landsat 8 OLI 2015 showed that the coastal city of Denpasar has erosion and accretion. Based on the results of overlap between the Landsat TM 2011 and Landsat 8 OLI 2015 the extent of erosion is about 258,877 m² and accretion about 591,536 m².

<table>
<thead>
<tr>
<th>Variable</th>
<th>Highly Invulnerable</th>
<th>Invulnerable</th>
<th>Medium</th>
<th>Vulnerable</th>
<th>Highly Vulnerable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geomorphology</td>
<td>High Cliff</td>
<td>Medium Cliff</td>
<td>Low Cliff, Alluvial Plain</td>
<td>Building, Estuary, Lagoon</td>
<td>Groin, Breakwater, Sandy Beach, Marsh, Swamp, Mud Flat, Delta, Mangrove, Reef</td>
</tr>
<tr>
<td>Elevation (m)</td>
<td>&gt; 10</td>
<td>6 – 9.9</td>
<td>4 – 5.9</td>
<td>2 – 3.9</td>
<td>&lt; 2</td>
</tr>
<tr>
<td>Shoreline (m/yr)</td>
<td>&gt; 2.0 Accretion</td>
<td>1.0 – 2.0</td>
<td>-1.0 – 1.0 Stable</td>
<td>-1.0 – 2.0 Erosion</td>
<td>Erosion</td>
</tr>
<tr>
<td>Tidal Range (m)</td>
<td>&lt; 0.5</td>
<td>0.5 – 1</td>
<td>1 – 1.5</td>
<td>1.5 – 2</td>
<td>&gt; 2</td>
</tr>
<tr>
<td>Wave Height (m)</td>
<td>&lt; 0.5</td>
<td>0.5 – 1</td>
<td>1 – 1.5</td>
<td>1.5 – 2</td>
<td>&gt; 2</td>
</tr>
</tbody>
</table>

Table 2: Rank of vulnerability

Results and Discussion

Results of shoreline change analysis using Landsat TM 2002 and Landsat 8 OLI 2015 showed that the coastal city of Denpasar has erosion and accretion. Based on the results of overlap between the Landsat TM 2011 and Landsat 8 OLI 2015 the extent of erosion is about 258,877 m² and accretion about 591,536 m².

Table 3: Vulnerability based on erosion data.

<table>
<thead>
<tr>
<th>No.</th>
<th>Location (Village)</th>
<th>Area (m²)</th>
<th>Erosion (m/year)</th>
<th>Vulnerability Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kesiman Petilan</td>
<td>32,599</td>
<td>-1.55</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Sanur Kaja</td>
<td>25,855</td>
<td>-2.19</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Serangan</td>
<td>183,133</td>
<td>-0.55</td>
<td>3</td>
</tr>
<tr>
<td>4</td>
<td>Pedungan</td>
<td>17,200</td>
<td>-0.92</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>258,877</strong></td>
<td><strong>-1.30</strong></td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

Table 4: Vulnerability based on accretion data.

<table>
<thead>
<tr>
<th>No.</th>
<th>Location (Village)</th>
<th>Area (m²)</th>
<th>Accretion (m/year)</th>
<th>Vulnerability Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sanur Kaja</td>
<td>19,044</td>
<td>0.99</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Sanur</td>
<td>52,519</td>
<td>0.67</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>Sanur Kauh</td>
<td>68,746</td>
<td>3.33</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Serangan</td>
<td>197,107</td>
<td>0.43</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>Pedungan</td>
<td>226,764</td>
<td>8.32</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>Sesetan</td>
<td>13,221</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>7</td>
<td>Sidakarya</td>
<td>14,135</td>
<td>0.78</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>591,656</strong></td>
<td><strong>2.22</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

Erosion which occurs in coastal areas of Denpasar is most significant in the Village of Kesiman Petilan. This is because of the absence of some forms of coastal protection in this area, such as a groin or breakwater. In addition, erosion might be also caused by currents or wind-generated
waves. Based on the erosion rate as shown in Table 3, the coastal area was ranked into vulnerable values.

The accretion is mainly caused by unnatural human activities. The reclamation activities such as coastal protection building (groin), world resort development plan (reclamation) and tourism (reclamation) are the main reasons causing the accretion. The results show that the rate of accretion in this area was 2.22 m / year.

Based on the identification of Landsat imagery 8 on February 10, 2015, land cover of the coastal city of Denpasar was classified into four types as shown in Table 5.

<table>
<thead>
<tr>
<th>No.</th>
<th>Land Cover</th>
<th>Area (m²)</th>
<th>Percentage (%)</th>
<th>Degree of Vulnerability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Estuary; lagoon; delta</td>
<td>1,831</td>
<td>43.7%</td>
<td>Vulnerable</td>
</tr>
<tr>
<td>2</td>
<td>Building and residence</td>
<td>65,816</td>
<td>56.2%</td>
<td>Highly Vulnerable</td>
</tr>
<tr>
<td>3</td>
<td>Sandy coast</td>
<td>68,692</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Mangrove forest</td>
<td>18,236</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>154,575</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

**Elevation**
With land heights ranging from 0-90 meters above sea level, the height difference was not too significant due to the topography of Denpasar being relatively low-lying and flat. The area was dominated by plain areas. Based on the data of Aster GDEM, the area was classified into several classes of vulnerability (Table 6).

<table>
<thead>
<tr>
<th>No</th>
<th>Location</th>
<th>Vulnerability Class</th>
<th>Area (m²)</th>
<th>Total Area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Coastal Zone of Denpasar</td>
<td>1 2 3 4 5</td>
<td>2,794,641</td>
<td>29,296.756</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>21,271,876</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4,883,906</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>346,333</td>
<td></td>
</tr>
</tbody>
</table>

**Tidal Ranges**
The Tide data obtained from the Indonesian Geospatial Information Agency in 2015 were calculated by the admiralty method. In 2015 the highest tide was as high as 1.191 meters which occurred in July, while the lowest tide, which occurred in January, was only 0.011 meters.

**Wave Height**
According to the analysis of wave height data from 2013 to 2014 obtained from Meteorological Climatology and Geophysics Agency, Surabaya and processed using Microsoft Excel. This was categorized as vulnerable with the wave height being 1.7 m.

**Sea Level Rise**
The data received from the Topex Poseidon-Jason I-Jason II (1993-2014) satellite imagery and then, processed numerically by using Ms.Excell shows that sea level rise was 1.74 millimeters / year

**Coastal Vulnerability Index**
Based on the Weighted Overlay and Weighted Sum methods of Arc-GIS 9.3 tool, relatively low erosion occurred in Mangrove areas and the waves were relatively weak. High levels of erosion occurred in the area which is located around the harbour and the settlement. Figure 1 shows a map of the coastal vulnerability index generated by satellite image data processing.
Conclusion

Based on analysis of the satellite image data, the coastal area of Denpasar might be classified into five categories, i.e.: 1. Highly invulnerable coastal area covering an area of ± 728,041 m² (3.18%). 2. Invulnerable coastal area covering an area of ± 5,813,509 m² (25.41%). 3. Medium coastal area covering an area of ± 2,515,037 m² (10.99%). 4. Vulnerable coastal area covering an area of ± 11,842,907 m² (51.78%). 5. Highly vulnerable coastal area covering an area of ± 1,971,119 m² (8.61%).

Acknowledgement
The authors gratefully acknowledge the Indonesian US Geological Survey for providing satellite image data. We also thank University of Brawijaya for supporting this publication. Our special thanks go to Ms. Jeannette Grundy of Victoria University, New Zealand, for her kind and professional proofreading.

References
Phytoremediation of Lead (Pb) For Ecosystems Contaminated Sidoarjo Mud Volcano Using Cat Tail (Typha latifolia L.)

Tarzan Purnomo
Ecology Laboratory, Biology Department, Faculty of Mathematics and Natural Sciences
Universitas Negeri Surabaya, Indonesia
Email address: tarzan_unesa@yahoo.co.id

Abstract
Hot mud that gushed in Porong Sidoarjo, East Java, Indonesia, has resulted in contamination of the aquatic ecosystem by heavy metals, especially lead (Pb). It required the efforts to overcome them through the application of remediation technology uses plants or phytoremediation. This study aims to determine the efficiency of the cat tail (Typha latifolia L.) as lead phytoremediator. Experiments conducted in the green house, Department of Biology, State University of Surabaya, for 2 weeks using a randomized block design, consisting of two treatments, namely biomass Typha latifolia L. (300, 600, and 900 grams/4 liters of water/1 kg sediment) and the detention time (7 and 14 days) with three repetitions. Parameters measured include research Pb levels in water, sediments, and the roots of Typha latifolia L., as well as physical-chemical parameters of water (temperature, pH, and salinity). Pb analysis using Atomic Absorption Spectrophotometer (AAS) in the laboratory of the Center for Health Laboratory Surabaya (Balai Besar Laboratorium Kesehatan Surabaya). Data were statistically analyzed using a 2-way analysis of variance and Duncan's Multiple Range Test (DMRT) at the confidence level (α = 0.05). Physical parameters of water chemistry were analyzed descriptively and quantitatively compared with the Standard of Quality Standards (East Java Governor Decree 45 of 2002; PP.No 82 2001; LH Decree 51 of 2004). The results of the study showed after phytoremediation Pb levels in water and sediment decreases so fulfill the quality standard. Decreased levels of lead in the water reaches 82.668 to 99.862%, and in sediments from 65.381 to 99.546%. Pb absorption capacity by Typha latifolia L. The optimum is achieved by biomass 600 grams with detention time of 7 days, that is equal to 99.450% of the water, and 99.433% of the sediment. Thus Typha latifolia L. efficient in absorbing and accumulating Pb. After phytoremediation Pb in the roots of Typha latifolia L. reached 0.893 to 1.953 ppm or 89.30 to 195.30% higher than the levels in the water. The accumulation of biomass was achieved in 900 gram and 14-day detention time. Thus Typha latifolia L. is phytoremediator Pb efficient.
Keywords: phytoremediation, lead, Sidoarjo mud volcano, *Typha latifolia* L.
ICEAI-1054
Use of Nano-SiO2 and Nano-Al2O3 as an Additive to Improve Strength Development of Fly Ash-Portland Cement Geopolymer
Tanakorn Phoo-Ngernkham | Rajamangala University of Technology Isan
Sakonwan Hanjitsuwan | Lampang Rajabhat University
Jirayut Suebsuk | Rajamangala University of Technology Isan
Prinya Chindaprasirt | Khon Kaen University

ICEAI-1062
Manufacturing Geopolymer Brick from Bottom Ash and Portland Cement
Sakonwan Hanjitsuwan | Lampang Rajabhat University
Tanakorn Phoo-Ngernkham | Rajamangala University of Technology Isan

ICEAI-1070
Comparison between Linear and Non-Linear Analysis of Slender Concrete Walls SubJECTED AXIAL LOAD WITH AN ECCENTRICITY
D. J. Lee | Seoul National University of Science and Technology
S. T. Oh | Seoul National University of Science and Technology
Y. S. Kim | Seoul National University of Science and Technology
S. H. Jeong | Seoul National University of Science and Technology
S. M. Jun | Seoul National University of Science and Technology

ICEAI-1083
Strength of Cement Stabilized Sulfate Silty Clay
Apichit Kampala | Rajamangala University of Technology Isan
Luan Suerpadgorn | Rajamangala University of Technology Isan
Wichien Sangaroon | Rajamangala University of Technology Isan
ICEAI-1091

Effects of Construction Joints and Axial Loads on Slip Behavior of RC Shear Walls

Rado Ramarozatovo | Nagoya Institute of Technology
Jun Hosono | Nagoya Institute of Technology
Taishi Kawai | Nagoya Institute of Technology
Susumu Takahashi | Nagoya Institute of Technology
Toshikatsu Ichinose | Nagoya Institute of Technology
ICEAI-1054
Use of Nano-SiO$_2$ and Nano-Al$_2$O$_3$ as an Additive to Improve Strength Development of Fly Ash-Portland Cement Geopolymer

Tanakorn Phoo-ngernkham$^{a,*}$, Sakonwan Hanjitsuwan$^b$,
Jirayut Suebsuk$^c$, Prinya Chindapasirt$^d$

$^{a,c}$ Research Center for Advances in Civil Engineering and Construction Materials, Dept. of Civil Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan, Thailand
E-mail address: *tanakorn.ph@rmuti.ac.th, jirayut.su@rmuti.ac.th

$^b$ Program of Civil Technology, Faculty of Industrial Technology, Lampang Rajabhat University, Thailand
E-mail address: hanjitsuwan@gmail.com

$^d$ Sustainable Infrastructure Research and Development Center, Dept. of Civil Engineering, Faculty of Engineering, Khon Kaen University, Thailand
E-mail address: prinya@kku.ac.th

Abstract
This article investigates the use of nano-SiO$_2$ and nano-Al$_2$O$_3$ as an additive on the mechanical properties and microstructure of fly ash (FA)-Portland cement (PC) geopolymer pastes. Geopolymer pastes are manufactured from FA and PC with FA:PC ratio of 90:10. Nano-SiO$_2$ and nano-Al$_2$O$_3$ are used as additives at the dosages of 0%, 1%, 2%, and 3% by weight of binder for making FA-PC geopolymer paste. The alkali solutions are 10M sodium hydroxide (NaOH) and sodium silicate (Na$_2$SiO$_3$) with constant alkaline liquid/binder (L/B) ratio of 0.60 and curing at ambient temperature. Test results show that the use of nano-SiO$_2$ as an additive in FA-PC geopolymer paste results in decreasing setting time, while the setting time of FA-PC geopolymer paste slightly decreases with increasing nano-Al$_2$O$_3$ content. The adding of 2% nano-SiO$_2$ and nano-Al$_2$O$_3$ is the optimum level for compressive and flexural strengths development resulting in a homogenous and dense matrix.

Keywords: Geopolymer, nano-SiO$_2$, nano-Al$_2$O$_3$, Compressive strength, Microstructure

1. Introduction
Ordinary Portland cement is used extensively as a cementitious material for construction and building, however, the process of producing Ordinary Portland cement emits a large amount of carbon dioxide (CO$_2$) to the atmosphere. The negative environmental impact must be reduced by a reduction in the use of Portland cement. Fly ash, bottom ash and agro-waste ashes can be
used as pozzolanic materials to reduce the use of Portland cement. Nowadays, geopolymer is receiving more attention as an alternative binder for use as building material.

Geopolymer is manufactured from rich-silica and alumina source materials such as fly ash, calcined kaolin, and blast furnace slag. In Thailand, fly ash from Mae Moh power station in the north with approximately 3 million output annually is receiving attention for use as source material. Chindapasirt et al. [1] claimed that it can be used as a starting material for making good geopolymer. However at ambient temperature, the fly ash geopolymer gives low strength and needs temperature curing at 40-75 °C for obtain reasonable strength [1, 2]. As this problem, Pangdaeng et al. [2] has tried to enhance the strength development of fly ash geopolymer by using Portland cement as an additive. The reaction of Portland cement and water is an exothermal process at ambient temperature, therefore, this should be beneficial to the strength development.

Currently, utilization of nanoparticles for the enhancement of the property of building materials is being investigated. Nano-SiO\(_2\) and nano-Al\(_2\)O\(_3\) are most commonly used because they are highly pozzolanic materials and consist of amorphous phase with a high specific surface area [3]. This research aims to determine the optimum composition of fly ash-Portland cement geopolymer paste with different nano-SiO\(_2\) and nano-Al\(_2\)O\(_3\) dosages where high compressive strength and dense microstructure can be achieved. The obtained results should be very beneficial to the understanding and to the future applications of this geopolymer composite material.

2. Methods

2.1 Materials
The materials used in this study are fly ash (FA) from Mae Moh power plant in northern Thailand, Portland cement (PC), nano-SiO\(_2\) (Si), and nano-Al\(_2\)O\(_3\) (Al). The alkali solutions in this study are 10M sodium hydroxide (NaOH) and sodium silicate (Na\(_2\)SiO\(_3\)) with 13.89% Na\(_2\)O, 32.15% SiO\(_2\), and 46.04% H\(_2\)O.

<table>
<thead>
<tr>
<th>Table 1: Chemical compositions of FA and PC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Materials</td>
</tr>
<tr>
<td>FA</td>
</tr>
<tr>
<td>PC</td>
</tr>
</tbody>
</table>
The chemical compositions and physical properties of FA and PC are illustrated in Tables 1 and 2. The FA consists of 29.32% SiO$_2$, 12.96% Al$_2$O$_3$ and 15.64% Fe$_2$O$_3$, and the high CaO content of 25.79%. The sum of SiO$_2$+Al$_2$O$_3$+Fe$_2$O$_3$ content of FA are 57.92%. The high calcium content suggest that it is a class C fly ash as specified by ASTM C618 [4]. The specific gravity, Blaine fineness, and average particle size of fly ash are 2.69, 4300 cm$^2$/g and 15.3 $\mu$m, respectively. While the PC had specific gravity of 3.16, Blaine fineness of 3600 cm$^2$/g and average particle size of 14.6 $\mu$m. The average particle sizes of Si and Al are 12 and 13 nm with specific surface areas (BET) of 200±25 and 100±15 m$^2$/g. The properties of Si and Al are illustrated in Table 3.

### Table 2: Physical properties of FA and PC

<table>
<thead>
<tr>
<th>Materials</th>
<th>Specific gravity</th>
<th>Average particle size (µm)</th>
<th>Blaine fineness (cm$^2$/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FA</td>
<td>2.69</td>
<td>15.3</td>
<td>4300</td>
</tr>
<tr>
<td>PC</td>
<td>3.16</td>
<td>14.6</td>
<td>3600</td>
</tr>
</tbody>
</table>

### Table 3: The properties of nano-SiO$_2$ and nano-Al$_2$O$_3$

<table>
<thead>
<tr>
<th>Materials</th>
<th>Average particle size (nm)</th>
<th>Specific surface area, BET (m$^2$/g)</th>
<th>Purity (%)</th>
<th>Appearance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si</td>
<td>12</td>
<td>200±25</td>
<td>&gt;99.98</td>
<td>White powder</td>
</tr>
<tr>
<td>Al</td>
<td>13</td>
<td>100±15</td>
<td>&gt;99.38</td>
<td>White powder</td>
</tr>
</tbody>
</table>

### Table 4: Mix proportions of geopolymer pastes

<table>
<thead>
<tr>
<th>Mix symbol</th>
<th>FA (g)</th>
<th>PC (g)</th>
<th>Si (g)</th>
<th>Al (g)</th>
<th>NaOH (g)</th>
<th>Na$_2$SiO$_3$ (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90FA:10PC</td>
<td>90</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:1Si</td>
<td>90</td>
<td>10</td>
<td>1</td>
<td>-</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:2Si</td>
<td>90</td>
<td>10</td>
<td>2</td>
<td>-</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:3Si</td>
<td>90</td>
<td>10</td>
<td>3</td>
<td>-</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:1Al</td>
<td>90</td>
<td>10</td>
<td>-</td>
<td>1</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:2Al</td>
<td>90</td>
<td>10</td>
<td>-</td>
<td>2</td>
<td>20</td>
<td>40</td>
</tr>
<tr>
<td>90FA:10PC:3Al</td>
<td>90</td>
<td>10</td>
<td>-</td>
<td>3</td>
<td>20</td>
<td>40</td>
</tr>
</tbody>
</table>

2.2 Mix proportion and mix detail

The mix proportions of geopolymer pastes are shown in Table 4. Liquid alkaline to binder ratio of 0.60, Na$_2$SiO$_3$ to NaOH ratio of 2.0 are fixed in this study. Geopolymer pastes are manufactured from FA and PC with FA:PC ratio of 90:10. The use of PC to partially replace FA because of the enhancement of strength development of FA geopolymer cured at ambient...
temperature based on previous study [2]. The Si and Al are used as additives into FA-PC geopolymer paste at the dosages of 0%, 1%, 2%, and 3% by weight of binder.

2.3 Setting time
The setting time of geopolymer pastes are tested in accordance with ASTM C191 [5].

2.4 Compressive and flexural strengths
After mixing, the 50x50x50 mm cube specimens are prepared for compressive strength test in accordance with the ASTM C109 [6]. While, the flexural strength of geopolymer pastes are obtained from modulus of rupture tests using 40x40x160 mm prisms in accordance with the ASTM C293 [7]. The specimens of compressive and flexural strengths were demoulded at the age of 1 day and immediately wrapped with vinyl sheet to protect moisture loss and kept in the controlled room. The compressive and flexural strengths are measured at the age of 28 days. The reported results are the average of three samples.

2.5 SEM analysis
The geopolymer pastes were broken at the middle portions for the SEM analyses. The specimen was placed on a brass stub sample holder with double stick carbon tape. The specimen was dried using infrared light for 5 min and then coated with a layer of gold approximately 20-25A thick using a blazer sputtering coater. The micrographs were recorded at 15 kV and 3,000x magnification.

3 Results
3.1 Setting time
Fig. 1 presents the setting times of FA-PC geopolymer pastes with different nano-SiO$_2$ and nano-Al$_2$O$_3$ as an additive. For the initial setting time of FA:PC:Si at 90:10:0, 90:10:1, 90:10:2, and 90:10:3 are 25, 22, 18, and 13 min, and the final setting time of pastes are 40, 34, 29, and 20 min, respectively. While the initial setting time of FA:PC:Al at 90:10:1, 90:10:2, and 90:10:3 are 25, 24, and 22 min, and the final setting time of pastes are 38, 35, and 31 min, respectively. The faster activation in setting time of FA-PC geopolymer pastes is found with the adding of nano-SiO$_2$ as an additive due to the increased reaction products within the geopolymer matrix. As mention, silica ions from nano-SiO$_2$ can react with calcium ions from FA and PC and form calcium silicate hydrate (C-S-H) [8]. For the adding of nano-Al$_2$O$_3$ as an additive, it is found that the setting time of geopolymer paste slightly decreases as the level of nano-Al$_2$O$_3$ increases.

From Fig. 1, the use of nano- Al$_2$O$_3$ as an additive gives a smaller effect on setting time of FA-PC geopolymer comparable to the use of nano-SiO$_2$ as an additive. This fast setting of FA-PC containing nano-SiO$_2$ is an advantage for use of this binder as repair binding materials.
3.2 Compressive and flexural strengths

Table 5 presents the compressive and flexural strengths of FA-PC geopolymer pastes with different dosages of nano-SiO$_2$ and nano-Al$_2$O$_3$. The compressive and flexural strengths of FA-PC geopolymer pastes increases as the adding levels of nano-SiO$_2$ and nano-Al$_2$O$_3$ increase. The compressive strengths of FA-PC geopolymer pastes at FA:PC:Si of 90:10:0, 90:10:1, 90:10:2, and 90:10:3 are 30.2, 34.1, 34.5, and 31.6 MPa, whereas the compressive strengths of FA:PC:Si at 90:10:1, 90:10:2, and 90:10:3 are 34.0, 36.0, and 32.9 MPa, respectively. This trend conforms to the results of flexural strength. The adding 2% of both nano-SiO$_2$ and nano-Al$_2$O$_3$ is the optimum level. The adding of 3% nano-particles starts to lower the strength development of FA-PC geopolymer paste. This is probably due to too high amount of SiO$_2$ and Al$_2$O$_3$ for the reaction to forms calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H) in a similar way as the pozzolanic reaction in the blended cement paste [9].

![Setting time of geopolymer pastes](image)

**Table 5: Compressive and flexural strengths of geopolymer pastes**

<table>
<thead>
<tr>
<th>Mix symbol</th>
<th>28-day compressive strength</th>
<th>28-day flexural strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>90FA:10PC</td>
<td>30.2</td>
<td>4.82</td>
</tr>
<tr>
<td>90FA:10PC:1Si</td>
<td>34.1</td>
<td>5.43</td>
</tr>
<tr>
<td>90FA:10PC:2Si</td>
<td>34.5</td>
<td>5.76</td>
</tr>
<tr>
<td>90FA:10PC:3Si</td>
<td>31.6</td>
<td>4.84</td>
</tr>
<tr>
<td>90FA:10PC:1Al</td>
<td>34.0</td>
<td>5.09</td>
</tr>
<tr>
<td>90FA:10PC:2Al</td>
<td>36.0</td>
<td>5.68</td>
</tr>
<tr>
<td>90FA:10PC:3Al</td>
<td>32.9</td>
<td>5.03</td>
</tr>
</tbody>
</table>

3.3 SEM analysis
The strength development can be explained by the condition of cementitious products via the SEM analysis. Fig. 2 shows the fracture surfaces of FA-PC geopolymer pastes with different nano-SiO$_2$ and nano-Al$_2$O$_3$ as additives cured at ambient temperature for 28 days. The 90FA:10PC mix (Fig. 2a) contains a number of nonreacted and/or partially reacted fly ash particles embedded in a continuous matrix. The paste mixed with 2% nano-SiO$_2$ (Fig. 2b) and 2% nano-Al$_2$O$_3$ (Fig. 2c) display less number of fly ash particles and more reaction products, and the fracture surfaces appear denser than that of the 90FA:10PC mix. The uses of nano-SiO$_2$ and nano-Al$_2$O$_3$ as an additive into FA-PC geopolymer paste results in the additional formations of calcium silicate hydrate (C-S-H), calcium aluminate hydrate (C-A-H) and sodium aluminosilicate hydrate (N-A-S-H) gels [9]. This leads to the overall increasing of strength development of geopolymer.

![Fig. 2: SEM of geopolymer pastes](image)

### 3.4 Acknowledgments

The authors gratefully acknowledge the financial supported from Rajamangala University of Technology Isan.

### 4 References


ICEAI-1062
Manufacturing Geopolymer Brick from Bottom Ash and Portland Cement

Sakonwan Hanjitsuwan\textsuperscript{a,}\textsuperscript{*}, Tanakorn Phoo-Ngernkham\textsuperscript{b}
\textsuperscript{a} Program of Civil Technology, Faculty of Industrial Technology, Lampang Rajabhat University, Thailand
E-mail address: hanjitsuwan@gmail.com
\textsuperscript{b} Research Center for Advances in Civil Engineering and Construction Materials, Department of Civil Engineering, Faculty of Engineering and Architecture, Rajamangala University of Technology Isan, Thailand
E-mail address: tanakorn.ph@rmuti.ac.th

Abstract
This article presents the use of Portland cement to improve the strength development of bottom ash geopolymer and also investigates the using bottom ash as fine aggregate for manufacturing geopolymer mortar. Bottom ash was replaced by Portland cement at the dosages of 0\%, 10\%, 20\%, and 30\% by weight of binder, while the bottom ash aggregate are used to replace local river sand for making fine aggregate in geopolymer material at the rates of 0\%, 25\%, 50\%, and 75\% by weight of total fine aggregate. Sodium hydroxide and sodium silicate solutions are used as liquid portions in the mixture. All geopolymer mortar are manufactured with the constant liquid/solid binder ratio of 0.70, sodium silicate to sodium hydroxide ratio of 2.0, sand/binder ratio of 1.5, and curing at ambient temperature. The results show that the use of Portland cement to replace bottom ash results in decreasing of setting time of geopolymer mortar, but an enhancement of strength development. The 30\% Portland cement replacement gives the highest compressive strength, which is 17.7 MPa at 90 days. Moreover, the compressive strength and density seems to decrease with increasing of bottom ash aggregate as fine aggregate. This research will enable bottom ash destined for landfill to be used in a sustainable manner as a precursor in geopolymer binder, which is significant from engineering, economical and environmental perspectives.

Keywords: Geopolymer, Bottom ash, Portland cement, Setting time, Compressive strength

1. Introduction
Geopolymer material is alkali-activated aluminosilicates with lower amount of carbon dioxide (CO\textsubscript{2}) footprint to the atmosphere than that of traditional Portland cement. Davidovits (2008) reported that it had very good properties as same as Portland cement. Geopolymer material is made from rich silica and/or alumina materials for use as starting materials. In Thailand, fly ash from Mae Moh power station in the north Thailand is receiving attention for use as the major
source because it had rich silica and alumina and consist of highly amorphous phase (Chindaprasirt et al., 2007; Rattanasak and Chindaprasirt, 2009).

Bottom ash (BA) is a by-product from the coal combustion. It consists of silica and alumina as same as fly ash, therefore, it can be used as a binder to produce geopolymer material. However, bottom ash had big particle, irregular shape and high porous (Demir et al., 2001, Sathonsaowaphak et al., 2009). There are less work to the using bottom ash as a source material for making geopolymer because of its disadvantage. As mention, the bottom ash needs grinding to getting a smaller particle size, however, the compressive strength from bottom ash geopolymer is still very low when cured at ambient temperature comparable to the using fly ash as a binder (Chindaprasirt et al., 2009; Sathonsaowaphak et al., 2009). Several works (Garcia-Lodeiro et al., 2011; Phoo-ngernkham et al., 2013) claimed that the using additive is an optional to an enhancement of fly ash geopolymer properties; that is Portland cement. Therefore, this research aims to investigate the using dosage of Portland cement to improve the strength development of bottom ash geopolymer and also investigates the using bottom ash as fine aggregate for manufacturing geopolymer mortar. The obtained results should be very beneficial to the understanding and to the future applications of geopolymer material.

2. Methods

2.1 Materials

The precursors used in this study are bottom ash (BA) from Mae Moh power plant in northern Thailand and ordinary Portland cement (PC). The as-received BA particle was classified by pass on sieve No. 80 before use as a precursor. The using dosage of PC to replace BA as calcium-rich material is very attractive due to its availability, low cost and additional of reaction products within geopolymer matrix as previous studied by Phoo-ngernkham et al. (2013). Therefore, PC was used as calcium-rich material in this study. The chemical compositions of BA mainly consists of SiO$_2$, Al$_2$O$_3$, CaO and some impurities. The sum of SiO$_2$, Al$_2$O$_3$ and Fe$_2$O$_3$ was 56.17%, and the CaO content was high at 28.51%, while PC mostly consists of CaO and SiO$_2$ as shown in Table 1. The alkali activators in the mixture are 10 molar sodium hydroxide (NH) and sodium silicate (WG) with 13.89% Na$_2$O, 32.15% SiO$_2$, and 46.04% H$_2$O. The NH was obtained from dissolving sodium hydroxide pellets in distilled water and allowed to cool down at room temperature. Local river sand (RS) and bottom ash aggregate (BAA) with specific gravities of 1.86 and 1.81, respectively, are used as fine aggregate for making geopolymer mortar.
The mix proportions of bottom ash and Portland cement geopolymer are summarized in Table 2. All geopolymer mortar are manufactured with the constant liquid/solid binder ratio of 0.70, sodium silicate to sodium hydroxide ratio of 2.0, and sand/binder ratio of 1.5. The abbreviations of BA0PC, BA10PC, BA20PC, and BA30PC with corresponding BA:PC weight ratios of 100:0, 90:10, 80:20, and 70:30 are the mixes used. For investigation of using BA as binder and BAA as fine aggregate, the abbreviations of BA0PC0BAA, BA0PC25BAA, BA0PC50BAA, and BA0PC75BAA with corresponding BAA:RS weight ratios of 0:100, 25:75, 50:50 and 75:20 are the mixes used.

2.2 Mix proportion and mix detail
The mix proportions of bottom ash and Portland cement geopolymer are summarized in Table 2. All geopolymer mortar are manufactured with the constant liquid/solid binder ratio of 0.70, sodium silicate to sodium hydroxide ratio of 2.0, and sand/binder ratio of 1.5. The abbreviations of BA0PC, BA10PC, BA20PC, and BA30PC with corresponding BA:PC weight ratios of 100:0, 90:10, 80:20, and 70:30 are the mixes used. For investigation of using BA as binder and BAA as fine aggregate, the abbreviations of BA0PC0BAA, BA0PC25BAA, BA0PC50BAA, and BA0PC75BAA with corresponding BAA:RS weight ratios of 0:100, 25:75, 50:50 and 75:20 are the mixes used.
2.3 Setting time
The setting time of geopolymer mortar were tested in accordance with ASTM C191.

2.4 Compressive strength
The 50x50x50 mm cube specimens are used for compressive strength test in accordance with the ASTM C109. The specimens were demoulded at the age of 1 day and immediately wrapped with vinyl sheet to protect moisture loss and kept in the controlled room. The compressive strengths are measured at the ages of 7, 28, and 90 days. The reported results are the average of three samples.

3. Results
3.1 Setting time
Test results of setting time of BA geopolymer with various PC replacements are shown in Fig. 1. The setting time of geopolymer mortar decreases as the addition levels of PC replacement increase. For the initial setting times of BA0PC, BA10PC, BA20PC, and BA30PC are 625, 68, 37 and 15 min, while the final setting times are 675, 70, 45 and 35 min, respectively. As shown in Fig. 1, the setting time of geopolymer mortar tends to obviously decreases with increase in PC replacement. The addition of calcium oxide had significantly accelerated the setting and hardening of BA geopolymer mortar as same as FA-PC geopolymer (Phoo-ngernkham et al., 2013). The calcium ions from PC can react with silicon and/or aluminium ions from BA to form calcium silicate hydrate (C-S-H) and/or calcium aluminosilicate hydrate (C-A-S-H) in a similar was as cement hydration products. However, the setting time of BA geopolymer seems to have longer than that of FA geopolymer as reported by Pangdaeng et. al., (2014). As mention, the initial and final setting times of FA geopolymer were 124 and 144 min, respectively. This is probably due to the characteristic of starting materials.
3.2 Compressive strength

The compressive strengths of BA geopolymer mortar with different dosages of PC and curing time are shown in Table 3. The compressive strength of BA geopolymer mortar increases with increase in both of PC replacement and curing time. For example, 7-day compressive strength of BA0PC, BA10PC, BA20PC, and BA30PC mortars are 1.4, 2.6, 7.0, and 10.2 MPa, respectively. Also, the compressive strength of BA geopolymer mortar increases with curing time for all of PC replacement levels, i.e., the compressive strength of BA20PC mortar at the ages of 7, 28, and 90 days are 7.0, 8.0, 13.9 MPa, respectively. This is in line of Si-Hwan et. al., (2012). The presences of SiO₂ and Al₂O₃ from BA and calcium ions from PC can react with high alkali solutions to forming calcium silicate hydrate (C-S-H) and/or calcium aluminosilicate hydrate (C-A-S-H) and geopolymer gel (N-A-S-H) gels (Pangdaeng et. al., 2014, Phoo-ngernkham et. al., 2015). This leads to strength development of geopolymer matrix.

Table 3: Compressive strength of geopolymer mortars

<table>
<thead>
<tr>
<th>Mixes</th>
<th>7 days (MPa)</th>
<th>28 days (MPa)</th>
<th>90 days (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA0PC</td>
<td>1.4</td>
<td>1.7</td>
<td>3.5</td>
</tr>
<tr>
<td>BA10PC</td>
<td>2.6</td>
<td>3.3</td>
<td>5.1</td>
</tr>
<tr>
<td>BA20PC</td>
<td>7.0</td>
<td>8.0</td>
<td>13.9</td>
</tr>
<tr>
<td>BA30PC</td>
<td>10.2</td>
<td>11.7</td>
<td>17.7</td>
</tr>
</tbody>
</table>

Table 4 presents the compressive strengths of geopolymer mortars at 28 days with different dosages of PC replacement levels and the using BAA as fine aggregate. The compressive strength decreases as the using BAA replacement level in RS increase for all of PC replacement level. As shown in Fig. 2, the 28-day compressive strength and density of BA-PC geopolymer
mortar with BA:PC ratio of 70:30 found that the decrease in both of compressive strength and density is more pronounced with increasing BAA replacement level, due to BA particles had too porous. This advantage of BA is highly desirable for lightweight structure member in term of lower the unit and sustainable utilization as source material in alternative binder in terms of engineering, economical and environmental perspectives. For example, the compressive strength of 0BAA, 25BAA, 50BAA and 75BAA mortars are 13.8, 10.4, 7.3, and 2.3 MPa, while the density are 1846.3, 1682.0, 1420.9 and 1312.4 kg/m$^3$, respectively.

<table>
<thead>
<tr>
<th>Mixes</th>
<th>0%BAA (MPa)</th>
<th>25%BAA (MPa)</th>
<th>50%BAA (MPa)</th>
<th>75%BAA(MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BA0PC</td>
<td>5.8</td>
<td>2.5</td>
<td>1.3</td>
<td>1.2</td>
</tr>
<tr>
<td>BA10PC</td>
<td>7.6</td>
<td>4.2</td>
<td>3.0</td>
<td>1.5</td>
</tr>
<tr>
<td>BA20PC</td>
<td>9.6</td>
<td>6.0</td>
<td>5.2</td>
<td>1.7</td>
</tr>
<tr>
<td>BA30PC</td>
<td>13.8</td>
<td>10.4</td>
<td>7.3</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Table 4: compressive strength of geopolymer mortars at 28 days

![Graph showing compressive strength and density of BA geopolymer mortar containing 30%PC replacement level with various BA as fine aggregate](image)

Fig. 2: Compressive strength and density of BA geopolymer mortar containing 30%PC replacement level with various the using BAA as fine aggregate

3.3 Acknowledgments
The authors gratefully acknowledge the financial supported National Research Council of Thailand (NRCT) under Lampang Rajabhat University to Dr. Sakonwan Hanjitsuwan (Grant no. 006/2559). The authors also would like to acknowledge the support of the Program of Civil Technology, Faculty of Industrial Technology, Lampang Rajabhat University.

4. References


ICEAI-1070
Comparison between Linear and Non-Linear Analysis of Slender Concrete Walls Subjected Axial Load with an Eccentricity

D. J. Lee,a  S. T. Ohb, Y. S. Kim,c  S. H. Jeongd, S. M. June

Civil Engineering, Seoul National University of Science and Technology, Korea
adjlee@seoultech.ac.kr, balicia@seoultech.ac.kr, c kysgood89@naver.com
dsin_hyo@naver.com, ejsmina@daum.net

Abstract
Slender concrete wall behavior subjected axially loading with an eccentricity can be accurately predicted using non-leaner analysis application program FEA modeled on the experimental test procedure. A numerical study was undertaken to verify the effectiveness of the Finite Element Analysis (FEA) in predicting the failure characteristics of reinforced concrete slender walls with openings. The existing experimental test results which were compression strength 47 MPa and 99.3 MPa, reinforced concrete slender walls; width-thickness ratio 40 with 25% opening at the center, and restrained top and bottom sides are adopted to model numerically. The numerical model was constructed by the nonlinear analysis application program FEA produced by MIDAS-IT. The three dimensional solid analysis considering concrete and reinforcement simultaneously using solid brick element defined the total strain crack model with elastic modulus in compression and brittle in tension is applicable. The ultimate axial loads with an eccentricity, load-deflection responses up to failure, lateral displacements and crack propagations predicted by the FEA were compared at 10 concrete compressive strengths by 24, 35, 47, 60, 70, 80, 90, 100, 120, 150 MPa using linear and non-linear analysis. The comparative study also confirmed that the FEA is a reliable and effective numerical modeling technique for determining ultimate load capacity of high strength concrete walls with high slenderness ratio and opening. Especially the maximum lateral displacements of wall around opening are investigated at the linear and non-linear mode and compared the test observations.

Keywords: Slender concrete walls, Axial loaded with an eccentricity, Finite element analysis, Lateral displacement, Crack propagation

1. Background/ Objectives and Goals

There are two simplified design equation for axially loaded wall panels given in the Australian Standard AS3600 (2009) and American Concrete Institute Code ACI-318 (2014). The Codes are restraints to walls with slenderness ratios of less than 32, and are not intended to be acceptable the concrete strength should be less than 55 MPa. From the recent research, the slender concrete wall with more than 32 of slenderness ratio is verified that has structural performance. However the use of slender concrete walls for tall building with high strength concrete is increasing. It is evident that more investigations are required of the slender walls with higher concrete strength and slenderness ratio. It is well known that
the concrete characteristic is stronger enough for the compressive strength rather than the tensile strength. There is a need to study how much are influenced about the slender concrete walls axially loaded with an eccentricity depending on the compressive strength. An experimental test focused on this was carried out by Lee (2008). Slender concrete wall behaviors subjected axially loading with an eccentricity can be accurately predicted to be modeled by the finite element method according to the experimental test procedure.

2. Method

The existing experimental test results which the applied compression strengths were 47 MPa and 99.3 MPa, reinforced concrete slender walls; width-thickness ratio 40 with 25% opening at the center, and restrained top and bottom sides are adopted to model numerically. The numerical model was constructed by the nonlinear analysis application program FEA produced by MIDAS-IT. The three dimensional solid analysis method of FEA considering the material properties of concrete and reinforcement simultaneously is used a solid brick element defined the total strain crack model in compression and the brittle model in tension. The ultimate load at failure, load-deflection responses up to failure, lateral displacements and crack propagations predicted by the FEA were compared with 10 types of concrete compressive strength by 24, 35, 47, 60, 70, 80, 90, 100, 120, 150 MPa between linear and non-linear analysis. The comparison of maximum lateral displacement and crack propagation between by FEA and experimental result shows the effectiveness of the use of the non-linear mode in numerical analysis of the slender concrete walls.

2.1 Experimental Model

A wall panel with openings was tested by Lee (2008), which is detailed in Figure 1. The wall panel produced was square type. The lengths and heights of the panels was 1600mm with a thickness of 40 mm. The wall was restrained top and bottom edges; slenderness ratio of height over thickness ratio was 40, and had one opening at the center. The opening sectional area ratio was 25% and the opening configuration was based on practical dimensions in common building situations. The tested wall panel was subjected a uniformly distributed axial load with an eccentricity of thickness over 6 resulting the whole section loaded in compression. The F41 mesh (yield strength of 450 MPa and the minimum tensile strength of 500 MPa) was embedded. The reinforcement ratio was 0.0031 satisfying the minimum requirement in Australian Standard and ACI code. The test result and load-displacement shows Table 1 and Figure 2 respectively.
A Finite Element Analysis (FEA) is applied to investigate structural behavior of concrete wall with opening. The concrete wall with opening tested by Lee is modeled numerically. Using the MIDAS FEA Version 3.4.0, a numerical model is produced to a wall of 1600 x 1600 x 40 mm with one opening of 400 x 400 mm, which shows in Figure 3. The elastic modulus of 29725 MPa, the Poisson’s ratio of 0.2 and compressive strength of 47.0 MPa and 99.3 MPa were

### Table 1: Comparison of Test and FEA

<table>
<thead>
<tr>
<th></th>
<th>Elastic modulus (MPa)</th>
<th>Shear modulus (MPa)</th>
<th>Concrete strength (MPa)</th>
<th>Tensile strength (MPa)</th>
<th>Ultimate load (kN)</th>
<th>Maximum deflection (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test1</td>
<td>29725</td>
<td>12385</td>
<td>47.0</td>
<td>2.5</td>
<td>294.3</td>
<td>5.3</td>
</tr>
<tr>
<td>Test2</td>
<td>29725</td>
<td>12385</td>
<td>99.3</td>
<td>5.0</td>
<td>503.3</td>
<td>6.5</td>
</tr>
</tbody>
</table>

![Fig. 1: Tested panel by lee (units: mm)](image)

![Fig. 2: Load-deflection response](image)

#### 2.2 Numerical Model

A Finite Element Analysis (FEA) is applied to investigate structural behavior of concrete wall with opening. The concrete wall with opening tested by Lee is modeled numerically. Using the MIDAS FEA Version 3.4.0, a numerical model is produced to a wall of 1600 x 1600 x 40 mm with one opening of 400 x 400 mm, which shows in Figure 3. The elastic modulus of 29725 MPa, the Poisson’s ratio of 0.2 and compressive strength of 47.0 MPa and 99.3 MPa were
identical with material properties of tested walls are adopted. The restraint condition is hinged supporting on the top and bottom edges. The lumped (non-consistent) load approach is used to convert a set of nodal loads on the top edge to simulate an uniformly distributed load at an eccentricity within the sectional core. It usually employs a lumping method in dividing the amount of element load. The total element load is simply divided up and applied as a series of point loads to the nodes that the element is connected.

![Numerical model made by MIDAS FEA](image)

Fig. 3: Numerical model made by MIDAS FEA

### 2.3 Comparison of Experimental Model and Numerical Model

Typical maximum lateral deflections ($\delta_{\text{max}}$) at failure and load-deflection response analyzed by FEA is presented in Figure 4 and 5 respectively. The effectiveness of the FEA is demonstrated through a comparison with the test results and observations in terms of the deformed shapes and the load-deflection response as well as the ultimate loads. The successful agreements of the comparisons are satisfied to endure the applicable numerical model of the concrete slender walls. Although more discrepancies exist between the test and FEA due to the limitations of experimental testing, the comparisons further confirm that the numerical model is the appropriate in terms of accuracy. Based on the convergence study, the numerical model is used to conduct comparative studies in the following section.
3. Results

In this chapter, the comparative study confirmed that the FEA is a reliable and effective numerical modeling technique for determining ultimate load capacity of between normal and high strength concrete walls with high slenderness ratio and opening. Especially the maximum lateral displacements of wall around opening are investigated at the linear and non-linear mode and compared with the test observations.

3.1 Linear mode analysis
The maximum lateral displacements are predicted by the linear mode of FEA. On the basis of 10 types of compressive strength, the maximum lateral displacements on the horizontal location upon the top of the opening were changed according to increase or decrease of compressive strength from normal strength to high strength indicated in Table 2 as well as the ultimate loads at failure. The maximum lateral deflection occurs at the mid-height of wall panels as a single curvature-deform shape led to the horizontal cracks at the center of walls. Although the maximum lateral displacements occur at the center of opening, the data is recorded at the 1000mm of height in order to figure out the deflected shape of wall panel horizontally.

<table>
<thead>
<tr>
<th>Location (mm)</th>
<th>Ultimate Loads, P (kN)</th>
<th>24</th>
<th>35</th>
<th>47</th>
<th>60</th>
<th>70</th>
<th>80</th>
<th>90</th>
<th>100</th>
<th>120</th>
<th>150</th>
</tr>
</thead>
</table>

The displacements between two test results and FEA are reasonably identical. Analyzed wall edge over center deformed ratio $L_1/L_5$ and mid over center deformed ratio $L_2/L_5$ are calculated of the average are $100.01\%$ and $97.89\%$ respectively. It means that at the edge of wall $L_1, L_2$ and center $L_5$ a crack occurs to start and propagates heading toward mid points $L_3$ and $L_7$. In order to figure out horizontal deformed shape in terms of varying concrete strength, the maximum lateral displacement ratio (displacement over ultimate load on the basis of the displacement ratio at the center of wall with concrete strength 24 MPa) is presented in Figure 6. It is obviously different with test observations.
3.2 Non-Linear mode analysis

In the non-linear mode using Newton-Raphson method it is applied to 0.1 of the initial load factor, 0.001 of the minimum load factor and 0.001 of the displacement norm in convergence criteria. The analyzed results are presented in Table 3. On the average, the analyses in 73.18% of given loads is stopped due to the limit of allowed displacements. Considering the safety factor, it is reasonable ultimate loads calculated by using the non-linear method.

The deformed shapes between two test results and FEA at the non-linear mode are identical. Analyzed wall edge over center deformed ratio $L_1/L_5$ and mid over center deformed ratio $L_2/L_5$ are calculated of the average are 79.16% and 83.66% respectively. It means that a crack occurs to start at the center of wall panel and propagates significantly heading to the edges both side horizontally. It is obviously identical with test observations. The displacement ratios of concrete strength are presented in Figure 7. The slope of the displacement ratio shows steep about 20~10% and decreases depending on the concrete strength increase as well as more steep around the opening.
1.3 Comparison between linear and non-linear mode analysis

Maximum displacement ratios in which are maximum and minimum among the nodes lined horizontally in linear and non-linear mode are presented in Figure 8. Maximum deflection on the nodes occurs at the center of the wall and minimum one occurs at the end of the wall in non-linear mode, on the other hand maximum one occurs at the center and end of the wall and minimum one occurs at the mid-point between the center and the end of the wall in linear mode. In linear mode analysis, the gap between maximum and minimum displacements is a little and
the maximum points are three on the horizontal line of the wall. Those are constant in spite of the concrete strength increase up to 150 MPa. In non-linear mode analysis, the gaps are decreasing from 21.5% to 9.5% correspond to the concrete strength from 24 MPa to 150 MPa. In the concrete strength of 60 MPa, the gap of 14% means that the crack mode is changing from bending crack in tension side to crushing in compression side. The displacement ratio is smoothly decreasing in terms of the concrete strength.

\[ y = 3.4355x^{-0.387} \]
\[ R^2 = 0.9829 \]

Fig. 8: Maximum displacements of concrete strength

The ultimate load analyzed in linear and non-linear mode between normal concrete strength and high strength is illustrated in Figure 9. The ultimate loads analyzed in non-linear mode are reasonably identical with two test results.
3.4 Comparison between experimental results and non-linear mode analysis

In the experimental results at failure indicated in Figure 10 shows that the cracks start at the mid height of opening and reach to the both end edges. The clear single crack at high concrete strength wall panel indicates to occur the crushing crack in compression side otherwise the several fine cracks in normal strength wall panel represents the bending crack in tension side.

![Image of experimental results](image1.png)

**Figure 10. Experimental results tested by Lee**

The displacement ratios graphs between Figure 6 and 7 shows 1) the deformed shape slope in non-linear analysis is clear to occur crack, 2) the slope decrease smoothly from around 60 MPa ; means changing fracture mode from the bending crack to the crushing crack, 3) the
slope around mid-height of opening is more steep indicates the cracks start the point otherwise the slope analyzed in linear mode indicates not match with test observation.

Therefore in this study it proposes to use non-linear mode in numerical model of concrete necessary.

2. Conclusion
In this study, the structural behavior of axially loaded slender concrete wall; ultimate loads, load-deflection response and crack propagation, is analyzed by the numerical program FEA in non-linear mode. The analyzed result in non-linear mode is identical with existing test observations indicated the model and procedure are appropriated.

Acknowledgements
This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by Ministry of Science, ICT and Future Planning (NRF-2013R1A1A1011316).

References
AS3600.(2009). Concrete Structures, Standards Australia, Sydney, Australia.
ICEAI-1083
Strength of Cement Stabilized Sulfate Silty Clay

Apichit Kampala\textsuperscript{a,}\textsuperscript{*}, Luan Suerpadgorn\textsuperscript{b}, and Wichien Sangaroon\textsuperscript{c} \\
\textsuperscript{a,b} Department of Civil Engineering, Faculty of Engineering, Rajamangala University of Technology Isan, KhonKaen Campus, Thailand \\
Email address: apc_kum@hotmail.com \\
\textsuperscript{c}Department of Chemistry, Faculty of Engineering, Rajamangala University of Technology Isan, KhonKaen Campus, Thailand

Abstract
This research has proposed the mechanism of strength deterioration in cement stabilized soil under sodium sulfate solution in the environment with variation in water content and curing time. Based on the test results that the unconfined compressive strengths of both of the sample soils, cement stabilized sulfate silty clay and natural silty clay, in the dry side of the optimum water content show similar results and both are slightly lower than those of the optimum water content and the wet side of optimum water content. This is due to the fact that water content in the dry side is insufficient for the hydration reaction. While the unconfined compressive strengths of the cement stabilized sulfate silty clay at the optimum water content and in the wet side are lower than those of the cemented stabilized natural silty clay. This is because the sample soils in these two environments have better hydration reaction than those in the dry-sided environment where sodium sulfate takes chemical reaction with calcium hydroxide, which is the product from the hydration reaction, and thus causing more severe impact on soil strength deterioration.

Keywords: Soil cement, Sulfate soil, Saline clay, Compactions, Strength.

1. Background/ Objectives and Goals
Saline soil is the soil which contains high volume of various types of soluble salts. There are two main types of saline soil which are chloride salt and sulfate salt. Chloride salts are typically found in seawater, brackish water, or within the soil layer in some areas (Grim, 1968; Mehta, 1986; Wild et al., 1999) as shown in Figure 1. Sulfate salts are typically found in soil or underground water (in some areas), polluted water in residential areas, polluted water from industrial factories or some of chemical generated factories including fertilizer producing factories, or some of natural hot springs. Most of sulfate salt found in soil is sodium sulfate and magnesium sulfate respectively (Obika and Freer-Hewish, 1990).
The deterioration process caused by sodium sulfate starts with the chemical reaction between sulfate ions (of sodium sulfate and magnesium sulfate) and compound substances of calcium hydroxide and calcium aluminate hydrate, which is the residue from the hydration reaction, resulting in gypsum and calcium sulfo aluminate (ettringite) which cause expansion and ruptures (Hunter, 1988; Mitchell, 1992; Wild et al., 1999; Puppala et al., 2004). On the other hand, the deterioration process by chloride starts with chemical reaction of chloride ions which reducing the concrete alkaline for iron rust protection property and if the critical point is reached, with sufficient water and oxygen, iron rust will occur (Chindaprasirt, 2007).

This research has thus studied the destructive mechanism from the influences of sulfate by examining the results of the compressive strength and microstructural of under the controlled variants which are water content and curing time.

2. Materials and Methods

Saline soil or sulfate soil
Sample soil is silty clay. The specific gravity of the sample is 2.72. The liquid limit and plastic limit is 68.3% and 38.1% respectively. The sample soil classified by Soil Classification (USCS) is Clay of high plasticity (CH). The graph of size distribution is shown in Figure 2. The sample sulfate silty clay has 2.8-3.0% sodium sulfate which is the critical level according to ACI standard (ACI., 1992).

Cement
Cement used in the test is Portland cement Type 1 which has specific gravity of 3.14. The grain of size distribution of cement is shown in Figure 2.
Methods
The following soil properties are used for the testing parameters of sample soils.

1) Modified proctor; tested according to ASTM 1557

2) Unconfined compression test; after curing time of the sample soils, soak the sample soil in water for 2 hours, then let it dry before tested by unconfined compressive strength test machine with the rate of 0.01 mm/minute.

Five samples were prepared for each of testing ratio and soil curing time. Under the same testing environment, the standard deviation less than 10% was examined. (SD <10%, defined for strength value)

3. Test Results
Figure 3 shows graph of compressive strength of sulfate silty clay varied by cement volume under the modified proctor. The results show the optimum water content (OWC) and maximum dry unit weight ($f_{dry,max}$) of sulfate silty clay of 16.56% and 18.5 kN/m³ respectively. When mixing with cement, the maximum dry unit weight increases according to the cement volume because cement has higher specific gravity than the sample soil; while the optimum water content decreases according to the increase of maximum dry unit weight.
Figure 3 Compaction curves of the cement stabilized sulfate silty clay.

Figure 4 shows development of unconfined compressive strength of silty clay and sulfate silty clay compressed under optimum water content (maximum dry unit weight) at 7 day curing time. The figure shows development rate of compressive strength of natural silty clay which can be divided into 3 zones. The first zone, low volume of cement content, is called soil-cement interaction zone. In this zone, the unconfined compressive strength increases along the increased volume of cement content. In the second zone, the unconfined compressive strength is rather stabilized. This second zone is called transitional zone. The last zone is the cement-soil interaction zone where unconfined compressive strength further increases along the increased volume of cement content. For the sulfate silty clay, it is found that in all levels of cement content, the unconfined compressive strengths are lower than those of natural silty clay. The development rate of natural silty clay is the same as that of sulfate silty clay, except in the cement-soil interaction zone (high volume of cement content) that the development rate of sulfate silty clay is lower than that of natural silty clay (see the slope of the graph).
Figure 5(a), (b) and (c) shows the relationship of unconfined compressive strength of cement stabilized silty clay and sulfate silty clay, with volume of water content tested at soil curing time of 7, 14, and 28 days respectively. From the figure, it shows that at all curing time duration, the unconfined compressive strength of both types of soils increase along the increase in water content and their peak is at the optimum water content (maximum dry unit weight). After the peak, the unconfined compressive strength decreases against the increase in water content. It also shows that the unconfined compressive strength of the dry side compression for both types of soil are similar to each other. While in the case of optimum water content and the wet side compression (water content higher that the optimum water content), their unconfined compressive strengths of natural silty clay are higher than those of sulfate silty clay. From this behavior, it shows that sulfate solution in soil has adverse effect only in complete hydration reaction scenarios as can be seen that in the dry side with insufficient amount of water for the hydration reaction, the strength of cement stabilized sulfate silty clay is lower than that of the cement stabilized natural silty clay. While at the optimum water content and the wet side, the influences of sulfate clearly reduce the strength of cement stabilized sulfate silty clay to be lower than that of the cement stabilized natural silty clay.
Figure 5: Relationship between compressive strength and water content of cement stabilized naturally silty clay and sulfate silty clay.
Figure 6(a), (b), and (c) show the photo of microscopic structure of soil-cement at 10% cement, varied by moisture content. Figure 7(a) shows the dry side of microscopic structure of soil-cement (80% moisture content of the optimum moisture content). The picture clearly shows the clay soil structure and the gaps of soil particles. It is possible that the water content for hydration reaction is low which consequently causes the low content of hydration byproduct. Figure 5(b) and (c) depict the microscopic structure wet side soil-cement which consist of the moisture content equal to the optimum moisture content and 120% of optimum moisture content respectively. From the figure, the byproducts of hydration reaction occurring in the particle gaps are clearly visible. It can be explained that when cement is mixed with soil and water, it causes hydration reaction resulting in the compound substance which are calcium silicate hydrate (C-S-H), calcium aluminate hydrate (C-A-H), calcium hydroxide (Ca(OH)$_2$) and calcium sulfo aluninate or ettringite (Chindaprasirt, 2007). The first two compound substances have joining property caused by the reaction with the main compound substances in cement. The by-product of joining expands into the soil particle gaps resulting in the strengthened soil (Wild et al., 1993; Harris, 2004; Rajsekaran, 2005). While the calcium hydroxide and calcium sulfo aluninate or ettringite are also the by-products of the main compound substance reaction, but do not have joining property. In sulfate soil, calcium hydroxide is ionized as calcium ion (Ca$^{2+}$) and has chemical reaction with the soluble sulfate (Mehta, 1973a, 1973b; Holm, et al., 1983; Kujala, 1983; Wild et al., 1993). The magnesium ion from magnesium sulfate (MgSO$_4$) has chemical reaction with calcium hydroxide Ca(OH)$_2$ resulting in magnesium hydroxide Mg(OH)$_2$ where by the high content of this compound substance will dissolve C-S-H which subsequently causing the reduction in compressive strength of sulfate soil-cement (Mitchell, 1986; Hunter, 1988; Wild et al., 1999; Puppala et al., 2004).

4. Concussions

The paper presents impacts of cement content, compressive water content and curing time on the compressive strength of cement stabilized soil with sodium sulfate solution. The results from the experiments can be concluded as following:

1) At a cement content value, the unconfined compressive strength of the natural silty clay increases along the increment of the compressive water content and is at its peak at the optimum water content. After the peak, the unconfined compressive strength decreases against the increment of the water content. In all curing timed environments, the development rate of unconfined compressive strength in the wet side of the optimum water content is higher than that of the dry side of the optimum water content due to the insufficient water amount for hydration reaction in the dry side.

2) The variation in the unconfined compressive strength of cement stabilized silty clay and sulfate silty clay with the water content shows that the unconfined compressive strength in the
dry side of both sample soils are similar to each other, while the unconfined compressive strengths at the optimum water content and in the wet side (water content higher than the optimum water content) of cement stabilized sulfate silty clay are lower than those of the dry side due to the destructive effect from the sodium sulfate solution which requires calcium hydroxide which is the product from the hydration reaction.

5. Acknowledgments
Acknowledgements: This work was supported by Rajamangala University of Technology Isan.

6. References

American Concrete Institute. (1992). ACI 201. 2R-92: Guide to Durable Concrete. ACI Committee 201.


ICEAI-1091
Effects of Construction Joints and Axial Loads on Slip Behavior of RC Shear Walls

Rado Ramarozatovo¹, Jun Hosono², Taishi Kawai³, Susumu Takahashi⁴, Toshikatsu Ichinose⁵
Nagoya Institute of Technology
Email address: ¹radoramaro@gmail.com, ²Exjun3210@gmail.com, ³Sarukurippu@gmail.com, ⁴Takahashi.susumu@nitech.ac.jp, ⁵ich@nitech.ac.jp

Abstract
This research paper is an analysis of an experiment conducted on four RC shear wall specimens. The tested specimens were built with same dimensions, but taking different variables, such as the use of construction joint and the application of axial loads. The main purpose of the research was to determine the relationship between axial loads, construction joints and slip behavior of each specimen when put under an earthquake simulating cyclic shear load. The results of the experiment allowed concluding that specimens built with construction joint slip and fail after reaching maximum moment strength, as the vertical bars of the web get cut. On the other hand, slip is negligible in monolithic specimen and the failure of the specimen occurs on concrete, rather than on reinforcement. The results also enlightened how the increase of axial load affects the reduction of the width of cracks, the increase of strength of the specimen and its capacity to dissipate energy.

Keywords: Slip, shear wall, axial load, construction joint

1. Introduction
Regarding seismic issues on RC walls, codes such as ACI or Eurocodes take in consideration the slip at the same level as shear or bending strength at design. To understand the slip behavior, its impact on the strength and the stiffness in a squat RC wall, it is rather important to investigate and predict the behavior of the structure. For that purpose, four wall specimens nearly identical with a span ratio of 0.56, are built, axially loaded and subjected to a horizontal shear force. The applied load is a reversed cyclic one, which simulates the effect of an earthquake. Design codes such as ACI and Eurocode are used to predict the slip strength of the specimen.

2. Experiment
2.1 Specimens
Four reinforced concrete wall specimens with the dimensions specified in Figure 2 are built to conduct the study. Scaled at 1/2.5, three of the four specimens are different from one another
by the intensity of axial load applied at the top of each one. The values of the axial loads are specified in Table 1. The specimens are separately cast from their bottom supports creating construction joints between the walls and the bottom supports. The construction joint is obtained by applying an Acrylic Resin Emulsion. The fourth specimen differs from the three by the absence of construction joint, making the bottom support and the wall monolithic.

The reinforcements of the web for all specimens are D4@80mm for vertical bars and D4@50mm for horizontal bars. Two boundaries are integrated in each specimen with 6D10 as main reinforcements, confined with D4@50mm ties. The reinforcements are designed with Japanese standard (Ref. AIJ, 2003) and detailed in Table 2 and Figures 1 and 2.

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Construction joint</th>
<th>Axial stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>J-N0</td>
<td>Yes</td>
<td>0 N/mm2</td>
</tr>
<tr>
<td>J-N1</td>
<td></td>
<td>1 N/mm2 (223kN)</td>
</tr>
<tr>
<td>J-N2</td>
<td>No</td>
<td>2 N/mm2 (446kN)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2: Reinforcements of specimens</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sections (mm)</td>
</tr>
<tr>
<td>Web 1860x120 (H=1050)</td>
</tr>
<tr>
<td>Boundaries 240x120</td>
</tr>
</tbody>
</table>

**Figure 1:** Reinforcement of the boundaries
Considering that Japanese code does not consider slip at the designing process, ACI 318, Eurocodes and T. Pauley’s formulas are used to verify the slipping capacity of the specimens. The formulas, despite their different origins, have the same components: The dowel action of the vertical reinforcements and the friction resistance of the construction joint. The slip of specimen was predicted as the computed slip strengths gave smaller values than shear strengths. Calculated values are shown with test results later.

The shear strength was computed using Japanese code (Ref. AIJ, 2010)

\[
Q_{su} = \frac{0.068p \cdot t_e^{0.23}(F_c + 18)}{\sqrt[10]{\frac{M}{Q \cdot D}} + 0.12} + 0.85 \sqrt{\sigma_{wh} \cdot \rho_{wh} + 0.1 \sigma_0} \cdot t_e \cdot j
\]

\( F_c \): Compressive strength of concrete  
\( \sigma_{wh} \): Yield strength of shear reinforcement  
\( j \): Stress center-to-center distance  
\( \sigma_0 \): Average axis stress  
\( t_e \): Thickness of the web  
\( M/Q \cdot D \): Shear-span ratio  
\( \rho_{wh} \): Horizontal shear reinforcement ratio

**Loading set-up and load cycles**

As shown in Figure 3, the axial load is applied with two center-hole hydraulic jacks placed on fixed steel plates on the rigid top stub of each specimen. At the two faces of the wall, the hydraulic jacks are attached to the bottom support with two φ26 PC bars. And in order to simulate the reversed cyclic load of an earthquake, two other hydraulic jacks are used to induce
horizontal load at the top of the specimens, at a height of 1200mm from the upper bound of the bottom support.

The deformations are measured with strains gauges fixed on the reinforcements and with differential transducers.

Concerning the loading, the first two cycles of the experiment are defined by loads values: 90kN and 180kN. Those values represent the provisional calculated loads, before and after cracks appearance on the concrete. Thereafter, the cycles are defined by the following drifts of the top of the specimen: 0.15%, 0.30%, 0.45%, 1.0%, 2.0%, 3.0%, and 4.0%.

3. Results and interpretations

3.1 Failure process

![Graphs showing shear force vs. drift for J-N0 and J-N1 specimens](image)
Figure 4 displays the shear force-drift of each specimen. The behavior of the specimen before any cut of reinforcements is represented by the black lines. During the loading in J-series, displacement is increased and cracks start appearing from 180kN cycle. After reaching the ultimate strength at 2.0% drift which corresponds to the computed ultimate moment strength, the reinforcements of the web start being cut. This phenomenon is followed by the loss of the strength of the specimen in the remaining cycles, represented in yellow lines. A difference can be observed regarding the drop of strength in J-N0 and J-N1 which is sudden at 2.0% drift, compared with that of J-N2 in whose drop occurs gradually until the end of the experiment. The reason of the drop of strength is explained in the next paragraph.

J-N1 specimen has been subjected to the dysfunction of the shear deformation measuring transducer at -2.0% cycle. Unable to do direct measure at -2.0%, the displacements were computed with the deformations ratio relationship:

\[ \text{Slip + Moment + Shear} = 100\% \]  

(2)

The obtained results caused the reduction of -1% of all displacements that occurred after -2.0% cycle, which allowed tracing Figure 4b.

In J-series specimens, the experiment ended with the cut of the vertical reinforcement of the web and the degradation of the concrete around the boundaries. The size of these degradations varies according to the specimen, as shown in Picture 1 and Figure 5. In the case of J-N2, in addition to the bars in the web, two vertical bars in the right boundary also got cut at -295kN load during the last -4.0% cycle. The absence of necking on the bars allows concluding that the cut is caused by shear failure. Picture 2 shows the vertical bars cut of the web and the boundary after the experiment.

The behavior of M-N2, compared with that of the J-series, stands out by its bigger flexural...
strength. Failure occurs at -2.0% cycle, when the concrete is sliced horizontally at about 1/3 height from the bottom support.

The comparison of the results from experiment and computation in Table 3 shows that the provisions about maximum flexural strength of each specimen agree with the experiment. Concerning the slip, though it is not the case of ACI formula, both Eurocodes and Paulay’s formulas agree that slip occurs before the ultimate moment strength, which is in accordance with the results of the experiment.

Picture 1: Degradation of specimen at the end of the experiment

(a) In the web (b) In the right boundary

Picture 2: Vertical bars cut in J-N2
3.2 Drop of strength and friction coefficient

In J-N0, the cause of the loss of strength is the cut of the vertical reinforcements of the web. This statement is verified by computing the shear strength of the cut bars with the Von Mises criterion relation:

$$\tau_y = \sigma_y / \sqrt{3}$$  \hspace{1cm} (3)

The value of the shear strength of the reinforcement of the web J-N0 is then:
\[ T = 34 \text{bars} \times 14 \text{mm}^2 \times \frac{382 \text{MPa}}{\sqrt{3}} = 105 \text{kN} \quad (4) \]

That value corresponds to the drop obtained during the experiment displayed in Figure 6. Taking the case of J-N2 however, the loss of strength during the experiment is bigger. Among other possible reasons, it is caused not only by the cut of reinforcement, but also by the degradation of the concrete around the boundaries and whose size is as stated earlier, different depending on the specimen. In other words, the loss of strength depends on the intensity of the applied axial load.

Regarding the overall strength of the specimens, the friction also takes a non-negligible part. As indicated in the red ellipse in Figure 6, the resistance of J-N0 around zero drift is very small, indicating small friction at the construction joint. To discuss the phenomenon, Figure 7a shows the relationship between the drift and the uplift of the specimen at the center of the construction joint. As indicated in the blue ellipse in Figure 7a, the uplift around zero drift increases as the drift amplitude increases (Figure 7c). This increase is caused by the residual plastic strains in the vertical reinforcement. In J-N2 as well as in J-N1, however, the application of axial loads causes a bigger resistance of the specimens to uplift, as pointed in the blue ellipse in Figure 7a. Therefore, the reduction of the uplift causes the increase of friction within the construction joint.

It is not an easy task to compute the drop of friction throughout a specimen; however, it is possible to understand its variation within the different specimens. To compare the variation of friction, axial and shear stresses relationship is represented in positive and negative cycles at 2.0%, 3.0% and 4.0% in Figures 8a and 8b. Shear stress is defined by the shear force divided by the horizontal section of the wall. The value of the shear force is taken at zero drift as indicated by the red points in Figure 8a, since at this stage, the dowel action does not take effect yet. The results in Figures 8a and 8b show that shear force increases along with the axial load. Moreover, the trend of the graphs, especially at 4%, is closely similar to the slope of the tangent of Mohr circles (\( \mu = 0.75 \)), indicated by the broken lines, which represents the friction coefficient. This comparison allows understanding that the friction is a variable that depends on the intensity of the axial stress.

**Figure 6:** Drop of strength in J-N0
3.3 Cracks patterns

Figure 9 compares the crack patterns of the specimens. The patterns in J-Series shows distinctive shear cracks and flexural cracks. Most of the shear cracks do not reach the compressive zone. Regarding the widths at 1.0% cycle, as represented in millimetre in Figure 9, axially loaded specimens J-N1 and J-N2 show smaller gaps, but the widest cracks are observed in M-N2. The cracks in the monolithic specimen are widely spread over the web and the boundaries. Moreover, flexural and shear cracks are joined and reach the bottom support in both the flexural tensile and compression zone. The low capacity of the specimen to slip caused the deformations to be focused on shear and flexure; but the excessive spread of cracks weakened the section of the concrete and ultimately leads to its failure.
3.4 Slip deformation

It is noted that slip deformation displayed in Figures 10a, 10b and 10c is about 1% smaller than the drifts in Figures 4, in the jointed specimens. Also, the incapacity of the monolithic specimen to slip is translated by the slim shape of the graph in Figure 10d. The shapes of the hysteretic responses in Figures 4 and Figures 11 are similar in the J-Series, which means that slip deformation defines most of the deformations in the specimens.

This affirmation is supported by Figure 11 which displays the detailed ratios of moment, shear and slip deformations at the peaks of each cycle, in each specimen. The blue lines represent the moment deformation ratios and the red lines, the sum of moment and shear deformation ratios. In J-series, the red curves tend to point to 100% at 0% deformation, meaning than the deformations at the initial cycles are caused by shear and moment only. As the cycles continue, the slip areas increases, which implies the increase of slip deformations. Between J-N1 and J-N2, no major differences can be remarked; however, the capacity of J-N0 to slip is bigger, especially during the positive initial cycles.

Finally, regarding M-N2’s diagram, the small slip area likewise confirms that slip is negligible compared to the flexural and shear deformations. In opposite with M-N2 of the present experiment, considerable amount of slip was observed in a monolithic specimen in similar previous experiment conducted on RC shear walls without axial load (Ref. HOSONO Jun, 2015). It was however noted that the ratio of slip of that monolithic specimen was smaller than that of a specimen with construction joint. That comparison allows concluding that the

Figure 9: Cracks patterns and comparison of widths of cracks in mm at 1.0% cycle
application of axial load is a variable that prevent or reduce slip in a monolithic specimen.

![Graph of shear force - slip relationship](image)

**Figure 10**: Shear force - slip relationship

![Graph of ratios of deformations at cycles](image)

**Figure 11**: Ratios of deformations at cycles

1.5 **Energy dissipation**

The comparison of the hysteretic behaviors of the J-series as in Figure 10 shows that the amplitude of the shear force is increased at slip equals zero, as so as the axial load. This variation of the amplitude translates the capacity of a specimen to dissipate energy. The energy dissipation is the value of the area enclosed within the load - displacement curve shown in Figure 12a. To neglect the difference of flexural strengths $Q_{mm}$ and displacement amplitude $\Delta\delta$ in each specimen, the rate of the energy was computed by dividing the energy by $Q_{mm} \cdot \Delta\delta$, the area of the blue rectangles in Fig. 12a. The results of such computation at 1.0% and 3.0% cycles are illustrated in Figure 12b. The graph in J-series tends to increase with the increase of axial load. Regarding M-N2, its energy dissipation is smaller of that of J-N2 at 1.0% cycle, which may confirm one of T. Pauley’s conclusion which states that the sliding shear along the base is the main cause of reduction of the ability of a specimen to dissipate energy, unless the specimen is subjected to a high axial Loading or special conditions (Ref. T. Paulay, 1982).
4. Conclusions

The results from the experiment set up to investigate about the effects of axial loads and construction joint on the slipping behavior of four RC shear walls specimen led to the following conclusions:

(1) In specimens with Acrylic Resin Emulsion construction joint, the experiment ends with all the vertical reinforcement in the web cut after reaching maximum moment strength.

(2) In monolithic specimen, slip is negligible and the failure of concrete is reached before any cut of reinforcement. The absence of slip in the monolithic specimen proves that the existence of construction joint is the factor of slip in an axially loaded shear walls.

(3) In sliding specimen, the increase of energy dissipation is proportional to the increase of the axial load on shear wall. However, based on the comparison with a monolithic specimen, slip is not a factor that reduces the capacity to dissipate energy.

(4) The shear force at zero displacement during cyclic loading increases linearly depending on the increase of the intensity of axial load. The relationship between the shear force and the axial load is represented by a friction coefficient of 0.75.

3. References

American Concrete Institute, “Building Code Requirements for Structural Concrete Structures”, ACI 318-11, 2011


Recommendation for Detailing and Placing of Concrete Reinforcement, Architectural Institute of Japan, 2003
AIJ Standard for Structural Calculation of Reinforced Concrete Structures, Architectural Institute of Japan, 2010
Chemical Sciences (1)/ Electrical Engineering (1)

**Wednesday, May 11, 2016**  
**09:30-10:30**  
**Room 1008**

**ICCBES-1065**  
Control of Enzyme-Like Gold Nanoparticles for Sensing of Heavy Metal Ions and Proteins  
Chih-Ching Huang | National Taiwan Ocean University

**ICCBES-1081**  
Pyridylidene-Mediated Dihydrogen Activation Coupled with Catalytic Imine Reduction  
Johanna Auth | University of Basel  
Andreas Pfaltz | University of Basel

**ICCBES-1085**  
Dehydrogenation Kinetic Improvement of LiBH4-MgH2 Composite by Doping with Activated Carbon Nanofibers as Hydrogen Storages for Fuel Cells  
Rapee Utke | Suranaree University of Technology  
Sophida Thiangviriya | Suranaree University of Technology

**ICCBES-1114**  
Fabrication of Conducting Polymer Nanowires Based on Edge Effect of Nanoimprint Lithography  
Gang Shi | Jilin University  
Lingxiao Liu | Jilin University  
Daren Xu | Jilin University  
Nan Lu | Jilin University

**ICCBES-1123**  
A Study on Torrefaction of Dimocarpus Longan Biomass  
Jung-Chin Tsai | Ming Chi University of Technology  
Yi-Tun Hsu | Ming Chi University of Technology
ICCBES-1124

Biomass Gasification in a Bubbling Fluidized Bed
Jung-Chin Tsai | Ming Chi University of Technology
Chiao-Sung Wu | Ming Chi University of Technology
Wan-Ju Li | Ming Chi University of Technology

ICCBES-1127

Preparation of Ni-doped TiO2 Photocatalysts and Their Photocatalytic Properties under Visible Irradiation
Cheewita Suwanchawalit | Silpakorn University
Apinat Reanpong | Silpakorn University

ICCBES-1128

Long-Term Stability of Dye-Sensitized Cells with Different Dye-Covered TiO2 Electrodes
Fang-Chi Chang | Ming Chi University of Technology
Shun-Chi Chen | Ming Chi University of Technology
Po-Tsung Hsiao | Industrial Technology Research
Jung-Pin Chiu | Industrial Technology Research
Yung-Liang Tung | Industrial Technology Research

ICCBES-1129

Effect of Carbon Sources on Performance of LiFePO4 Cathode Materials
Wen-Chen Chein | Ming Chi University of Technology
Tzu-Sheng Chen | Ming Chi University of Technology
Chia-Hsuan Li | Ming Chi University of Technology

ICCBES-1152

Histone Deacetylase Inhibition of Minor Phenolic Compounds from Zingiber Officinale and Molecular Docking Stud
Pakit Kumboonma | Khon Kaen University
Thanaset Senawong | Khon Kaen University
Somprasong Saenglee | Khon Kaen University
Khatcharin Siritong | Khon Kaen University
Chavi Yenjai | Khon Kaen University
Chanokbhorn Phaosiri | Khon Kaen University
ICCBES-1157
Chemical Composition and Biological Activities of Essential Oil from Fine Scrap and Short Stem Virginia and Burley Tobacco (Nicotiana Tabacum L.)
Chatchanok Sansri | Chiang Mai University
Aphiwat Teerawutgulrag | Chiang Mai University
Jiraporn Kulsarin | Chiang Mai University

ICCBES-1158
Synthesis of Diamondback Moth (Plutella Xylostella (L.)) Sex Pheromone
Rachaneebhorn Inkum | Chiang Mai University
Aphiwat Teerawutgulrag | Chiang Mai University
Jiraporn Kulsarin | Chiang Mai University
Wipanoot Baison | Chiang Mai University

ICCBES-1162
Study on the Synthesis of Styrenated Phenol Using Organometallic Catalysts
Seokwhan Son | Sunchon National University
Seungmin Lee | Sunchon National University
Hogeun Ahn | Sunchon National University
Hyunjun Yun | Sunchon National University
Minchul Chung | Sunchon National University
Wonbong Kwak | SFC. Co., Ltd.
Sunghun Jung | SFC. Co., Ltd.

ICCBES-1165
Preparation of Styrenated Phenol by Alkylation of Phenol with Styrene over H₂SO₄-Treated M₆O₇ Catalysts
Jangho Cho | Sunchon National University
Hyeonjun Yun | Sunchon National University
Minchul Chung | Sunchon National University
Seokwhan Son | Sunchon National University
Ho-Geun Ahn | Sunchon National University
Yeongho Lee | Sunchon National University
Eun Ju Shin | Sunchon National University
Wonbong Kwak | SFC. Co., Ltd.
Sunghun Jung | SFC. Co., Ltd.
ICCBES-1173
The Investigation of Applications of TiO2 Nanomaterials in Rutile and Anatase Structures onto Denim Fabric
Özlen Altun | Trakya University
Nilgün Becenen | Trakya University

ICCBES-1174
Manganese Cyclohexane Dicarboxylic Acid: Synthesis and Examination of its Properties
Gühergül Uluçam | Trakya University
Özlen Altun | Trakya University

ICCBES-1175
ZnO and Ag Nanomaterials: Applications onto Denim Fabric
Nilgün Becenen | Trakya University
Özlen Altun | Trakya University

ICCBES-1185
Preparation of MoS2 Based MRI Contrast Agent for in Vivo Bio-Imaging
Hsieh-Chih Tsai | National Taiwan University of Science and Technology

ICCBES-1203
Folate-Targeted and Thermo-Responsive Mixed Micelles for Photothermal and Photodynamic Therapy
Tung-Yun Wang | National Chung Cheng University
Yu-Ying Chien | National Chung Cheng University
Ching-Yi Chen | National Chung Cheng University

ICCBES-1204
Colloidal Stability of Poly (Sulfobetaine Methacrylate)-Grafted Gold Nanoparticles in Protein Solutions
Chia-Chang Fan | National Chung Cheng University
Chen Ching-Yi | National Chung Cheng University
Comparison of Effect of Non-Meat Natural Ingredients on Physico-Chemical Properties of Pork Emulsion

Sangkeun Jin | Gyeongnam National University
Sungho Kim | Gyeongnam National University
Sora Ha | Gyeongnam National University
Heejun Jung | Gyeongnam National University
Chulwook Kim | Gyeongnam National University
Jaeyoung Kim | Gyeongnam National University
Taewan Kim | Gyeongnam National University
Samwoong Kim | Gyeongnam National University
Jaegim Ha | Gyeongnam National University
Eunmi Lee | Gyeongnam National University
Jungseok Choi | Gyeongnam National University

The Effects of VO$_4$ Substitution on the Sintering and Microwave Properties of Ca$_4$(La$_4$Pr$_2$)(SiO$_4$)$_4$(PO$_4$)$_2$O$_2$ and Ba$_4$(La$_4$Pr$_2$)(SiO$_4$)$_6$O$_2$

Hong Bo Yang | Tatung University
Y-J Lin | Tatung University
S-F Wang | National Taipei University of Technology

Effective Suppression of PdSn4 Growth in the Solder Joints with Pd substrate by Minor Ga Additions

Chaohong Wang | National Chung Cheng University
Kuan-ting Li | National Chung Cheng University

Thermal Instability Study of Electrolytes Reacted with Various Lithiated Cathode Materials of lithium-Ion Battery by DSC

Chih-Yi Lee | National United University
Yih-Shing Duh | National United University
Kai-Syuan Lin | National United University
Chen-Shan Kao | National United University
ICCBES-1288
Surface Modification of NF270 for Enhancing Antifouling Ability and PPCP Rejection
Yi-Li Lin | National Kaohsiung First University of Science and Technology
Jia-Zheng Tsai | National Kaohsiung First University of Science and Technology
Nai-Yun Zheng | National Kaohsiung First University of Science and Technology
Pei-Tsi Chen | National Kaohsiung First University of Science and Technology
Yu-Chi Chen | National Kaohsiung First University of Science and Technology

ICCBES-1103
Potential Application of Carbon Materials in Reducing Toxicity of Human Islet Amyloid Polypeptide
Li Wang | Jilin University
Shoujun Zhu | Jilin University
Tong Lu | Jilin University
Guangji Zhang | Jilin University
Fei Li | Jilin University

ICEAI-1012
Interfacial Reactions of Lead-Free Solders with the Ni-xPd Alloys
Pei Yu Chen | National Taiwan University of Science and Technology
Yi Shan Li | National Taiwan University of Science and Technology
Yee Wen Yen | National Taiwan University of Science and Technology
ICCBES-1065
Control of Enzyme-Like Gold Nanoparticles for Sensing of Heavy Metal Ions and Proteins

Chih-Ching Huang
Department of Bioscience and Biotechnology, National Taiwan Ocean University, Taiwan
Email: huanging@ntou.edu.tw

Functional logic gates based on lead ions (Pb\(^{2+}\)) and mercury ions (Hg\(^{2+}\)) that induce peroxidase-like activities in gold nanoparticles (Au NPs) in the presence of platinum (Pt\(^{4+}\)) and bismuth ions (Bi\(^{3+}\)) are presented. The “AND” logic gate is constructed using Pt\(^{4+}\)/Pb\(^{2+}\) as the input and the peroxidase-like activity of the Au NPs as the output; this logic gate is denoted as “Pt\(^{4+}\)/Pb\(^{2+}\) (AND)—Au NP\(_{POX}\).” When Pt\(^{4+}\) and Pb\(^{2+}\) co-exist, strong metallophilic interactions (between Pt and Pb atoms/ions) and aurophilic interactions (between Au and Pb/Pt atoms/ions) result in significant increases in the deposition of Pt and Pb atoms/ions onto the Au NPs, leading to enhanced peroxidase-like activity. The “INHIBIT” logic gate is fabricated by using Bi\(^{3+}\) and Hg\(^{2+}\) as the input and the peroxidase-like activity of the Au NPs as the output; this logic gate is denoted as “Bi\(^{3+}\)/Hg\(^{2+}\) (INHIBIT)—Au NP\(_{POX}\).” High peroxidase-like activity of Au NPs in the presence of Bi\(^{3+}\) is a result of the various valence (oxidation) states of Bi\(^{3+}\) and Au (Au\(^{7+}/Au^{0}\)) atoms on the nanoparticle’s surface. When Bi\(^{3+}\) and Hg\(^{2+}\) co-exist, strong Hg–Au amalgamation results in a large decrease in the peroxidase-like activity of the Au NPs. These two probes, (Pt\(^{4+}\)/Pb\(^{2+}\) (AND)—Au NP\(_{POX}\) and Bi\(^{3+}\)/Hg\(^{2+}\) (INHIBIT)—Au NP\(_{POX}\)), allow selective detection of Pb\(^{2+}\) and Hg\(^{2+}\) down to nanomolar quantities. In addition, we prepared nanocomposites of aptamer-modified Au NPs immobilized on bismuth oxychloride (BiOCl) nanosheets (Apt–Au NPs/BiOCl) with peroxidase-like activity for the detection of vascular endothelial growth factor-A\(_{165}\) (VEGF-A\(_{165}\)). The as-prepared nanocomposites exhibit high peroxidase-like activity for the catalytic conversion of Amplex Red (AR) to fluorescent resorufin in the presence of H\(_2\)O\(_2\). The catalytic activity of Apt–Au NPs/BiOCl nanocomposites is suppressed by vascular endothelial growth factor-A\(_{165}\) (VEGF-A\(_{165}\)) molecules that specifically interact with the aptamer units (Del-5-1 and v7t-1) on the nanocomposite surface. The AR/H\(_2\)O\(_2–\)Apt–Au NPs/BiOCl nanocomposites probe shows high selectivity (>1000-fold over other proteins) and sensitivity (detection limit ~0.5 nM) for the detection of VEGF-A\(_{165}\). Furthermore, the probe is employed for the detection of VEGF isoforms and for the study of interactions between VEGF and VEGF receptors.

Keywords: enzyme; gold nanoparticles; heavy metal ions; proteins; VEGF
ICCBES-1081
Pyridylidene-Mediated Dihydrogen Activation Coupled with Catalytic Imine Reduction

Johanna Auth and Andreas Pfaltz
Department of Chemistry, University of Basel, Switzerland
Email address: johanna.auth@unibas.ch

1. Background/ Objectives and Goals
In recent years dihydrogen activation at non-metallic centers has found increasing attention. Here we report a system in which dihydrogen is trapped by a pyridylidene intermediate that is generated from a pyridinium salt and base.

2. Methods
We envisioned a system in which dihydrogen is trapped by a pyridylidene intermediate that is generated from a pyridinium salt and base. Dihydropyridine resulting from $\text{H}_2$ addition to a pyridylidene can act as reducing agent toward organic electrophiles. By coupling the hydrogen activation step with subsequent hydride transfer from the dihydropyridine to an imine, a catalytic process could be established.

3. Expected Results/ Conclusion/ Contribution
We turned our attention to a pathway involving a pyridylidene intermediate. After initial unsuccessful experiments with $N$-aryl Hantzsch esters and nicotinamide derivatives, we chose 3,5-triaryl 2-pyridinium salt for further investigations because it had been shown by Itami and coworkers to form pyridylidene in the presence of a strong base. DFT calculations performed on the reaction of pyridylidene with $\text{H}_2$ predicted a relatively low activation energy of 20 kcal/mol for the concerted addition of $\text{H}_2$ to the carbenoid center, suggesting that the proposed reaction would feasible within a chemically reasonable temperature range. The calculated transition state closely resembles that reported for the analogous reaction of aminocarbene. The $\text{H}1$ atom of dihydrogen interacts with the filled sp² orbital carbenoid C atom with a bond distance of 1.21 Å, while the H1-H2 distance elongates to 1.23 Å. The H2 atom is located 2.33 Å away from this C atom with a H1-C-H2 angle of 146.5º.

Encouraged by these results, we prepared the pyridinium salt following the reported procedure and explored its reactivity towards $\text{H}_2$ under the conditions described for the generation of pyridylidene. Upon treatment of the pyridinium salt with 2.25 equivalents of Li bis(trimethylsilyl)amide (LiHMDS; 1M in THF) in THF or mixtures of THF/toluene as solvent at r.t for 20 min, and subsequent stirring under $\text{H}_2$ atmosphere (1-100 bar) at elevated temperature, traces of 1,2-dihydropyridine were detected, while in pure toluene conversion to
1,2-dihydropyridine increased to 13-33%. When pyridinium salt was reacted according to this protocol with 2.25 equivalents of LiHMDS for 5 hours in toluene at 50 °C under 10 bar of H2, conversion to 1,2-dihydropyridine reached 71% conversion. Furthermore, raising the pressure to 50 bar led to full conversion (Scheme 7). In order to confirm that the dihydropyridine was indeed formed by addition of H2 to a pyridylidene intermediate, control experiments were run using D2 gas instead of H2. When the reaction was conducted under the standard reaction conditions established in the experiments with H2 gas (50 bar D2, 50 °C, 5 h) clear evidence of deuterium incorporation into the dihydropyrdine was found. The 2H NMR spectrum showed a signal at the expected position at 4.30 ppm, which is very close to the chemical shift of the CH2 group of authentic 10 at 4.31 ppm in the 1H NMR spectrum.

We next explored the possibility to couple H2 activation with an in situ hydride transfer to an organic substrate. An Imine was chosen as model substrate because it does not contain acidic protons and, secondly, is expected to be a good hydride acceptor due to the electron-withdrawing CF3 group. When a 1:1 mixture of the imine and the pyridinium salt was subjected to the optimized conditions for H2 activation for 5 hours, 48% conversion to the corresponding amine was observed, along with 30% of pyridinium salt, and 70% of dihydropyridine. Extension of the reaction time to 13 hours afforded the amine in 95% conversion, along with 5% of unidentified byproducts. Based on these very promising results, we are currently investigating different classes of imine to develop a catalytic reduction to the corresponding amines.

Keywords: Pyridinium salts, dihydrogen activation, pyridylidenes, catalytic hydrogenation
ICCBES-1085
Dehydrogenation Kinetic Improvement of LiBH₄-MgH₂ Composite by Doping with Activated Carbon Nanofibers as Hydrogen Storages for Fuel Cells

Rapee Utke and Sophida Thiangviriya
School of Chemistry, Institute of Science, Suranaree University of Technology, Thailand
E-mail address: rapee.g@sut.ac.th

1. Background/ Objectives and Goals
Reactive hydride composite (RHC) of LiBH₄-MgH₂ is one of the most outstanding solid state hydrogen storages for fuel cells in onboard applications due to its high theoretical hydrogen capacity of 11.4 wt. %. However, sluggish dehydrogenation kinetics (up to 25 h to liberate 10 wt. % H₂ at 400 °C) obstructs its practical uses. In the present work, we would like to propose the enhancement of dehydrogenation kinetics of LiBH₄-MgH₂ composite by doping with activated carbon nanofibers (ACNFs). ACNFs with high surface area and porosity as well as good thermal conductivity are expected to introduce the hydrogen diffusion pathway and promote heat transfer for de/rehydrogenation.

2. Methods
Polyacrylonitrile (PAN)-based nanofibers were prepared by electrospinning technique of PAN solution in N,N-dimethylformamide. PAN-based nanofibers were treated at 280 °C and with concentrated KOH solution and pyrolyzed at 1000 °C to obtain activated carbon nanofibers (ACNFs). Hydride composite was prepared by milling LiBH₄ and MgH₂ under 2:1 (LiBH₄-MgH₂) molar ratio, denoted as 2Li-Mg. The composite of 2Li-Mg was doped with 1, 5, 10, 20, and 30 wt. % ACNFs to obtain 2Li-Mg-1%, 2Li-Mg-5%, 2Li-Mg-10%, 2Li-Mg-20%, and 2Li-Mg-30%, respectively. All samples were treated at 310 °C under 60 bar H₂ for 45 min. Powder X-ray diffraction (PXD) was performed to identify phases formed during de/rehydrogenation. Unit cell parameters of the samples were analyzed by using a TOPAS software with a Le Bail structural refinement. Dehydrogenation profiles were characterized by a temperature programmed desorption (TPD) technique. For de/rehydroegantion kinetics and reversibility, titration measurements using a laboratory set-up of Sievert-type apparatus were carried out.

3. Expected Results/ Conclusion/ Contribution
To identify phases formed in as-prepared samples, XRD patterns and refinements are considered. It was found that unit cell parameters of hydride materials could be altered by doping with small amount of ACNFs, i.e., 1-10 wt. %. This could be due to the fact that at low contents (1-10 wt. %) good dispersion of ACNFs in hydride matrices is achieved. The latter
could lead to the improvement of hydrogen diffusion pathway and de/rehydrogenation kinetics.

Afterwards, dehydrogenation profiles based on temperature and hydrogen content released were determined by H$_2$-TPD technique. From Figure 1, it should be remarked that by doping ACNFs into 2Li-Mg reduction of main dehydrogenation temperatures are up to $\Delta T=63$-$73$ and 56 $^\circ$C for MgH$_2$ and LiBH$_4$, respectively, and onset dehydrogenation temperature is up to $\Delta T=50$ $^\circ$C. Besides, by doping with ACNFs faster dehydrogenation kinetics is obtained, for example, in the same temperature range of room temperature to 500 $^\circ$C, 2Li-Mg liberates 70 % of theoretical hydrogen capacity, while milled samples doped with ACNFs give up to 83 % (2Li-Mg-30%) (Figure 1). Improvement of kinetic properties and reduction of dehydrogenation temperature obtained from milled samples doped with small amount of ACNFs (1-10 wt. %) could be due to the effect of well dispersed ACNFs in hydride matrices. For higher ACNFs content (20-30 wt. %), since no evidence based on changes of cell parameters is observed, the performance of hydride material is developed mainly by good thermal conductivity of ACNFs.
Kinetic improvement during dehydrogenation of 2Li-Mg doped with ACNFs was confirmed by titration measurements at 400 °C under vacuum. From Figure 2, hydrogen content released from 2Li-Mg is 6.2 wt. % H₂ within 9 h, while those of 2Li-Mg-1%, 2Li-Mg-10%, and 2Li-Mg-30% are in the range of 8.0-8.4 wt. % H₂, i.e., up to 35 % of hydrogen content of 2Li-Mg enhances under the same temperature, pressure, and time conditions by doping with ACNFs.
Keywords: Carbon, catalytic doping, solid state hydrogen storage, nanofibers, hydrides

Figure 2. Dehydrogenation kinetics of as-prepared samples of 2Li-Mg with and without ACNFs.
Conducting polymers have been applied in different devices, such as field-effect transistors (FETs), energy-storage devices, integrated circuits and sensors. For these applications, it is desirable to develop a simple and cost-efficient fabrication process. Nanoimprint lithography (NIL) possesses the significant advantages of low cost, high throughput, high reproducibility, and enviable resolution of a few nanometers over large areas. However, nanostructures are normally fabricated by using the costly stamp of nanostructures in the progress of NIL. Therefore, to lower the expense of the nanoscale stamp still attracts increasing attention.

Herein, we report a cost efficient technique to fabricate the high-resolution conducting polymer wires. This method includes the fabrication of stamp of nanoscale structures by utilizing the edge effect of NIL, and fabrication of high-resolution conducting polymer wires with the fabricated stamp by NIL. By controlling the imprinting process, the widths of the polypyrrole (PPy) wires can be adjusted easily.

In summary, with this method, the conducting polymer nanowires of 93 nm in width are fabricated, which is much smaller than that of the original microscale stamp. The resulting conducting-polymer nanowires exhibit excellent sensitivity to ammonia. This method may provide an alternative technique to construct other organic nanoelectronic devices.

Keywords: Conducting polymer, nanowires, sensitivity, edge effect, nanoimprint lithography
A Study on Torrefaction of Dimocarpus Longan Biomass

Jung-Chin, Tsai* and Yi-Tun, Hsu
Department of Chemical Engineering, Ming Chi University of Technology, Taiwan
E-mail address: jctsai@mail.mcut.edu.tw

1. Background/Objectives and Goals
Torrefaction is the technology to covert biomass into biofuel. This technology is a thermochemical process, with a processing temperature between 200°C to 400°C. Low temperature torrefaction is conducted in an atmospheric pressure and hypoxia environment; therefore, the torrefaction process is a slow and moderate method of fragmentation. The biofuel produced by torrefaction of this technology is characterized by low moisture and excellent combustion efficiency. Although the thermal mass/caloric is slightly lower than coal, to improve the utilization rate of biomass energy, many countries regard biofuel as a biomass energy source of high potential, which can replace burning coal to a certain degree. Therefore, torrefaction is the preprocessing step for conversion of biomass into biofuel. Thermal treatment will damage fibrous structure and the tenacious biomass, and the biofuel after torrefaction has hydrophobic characteristics and biofuel energy density is higher than the original biomass, rendering biofuel more attractive to academic research.

In general, torrefaction experiment is time consuming, thus, many studies adopt the thermoanalysis technology in torrefaction experiments in order to shorten the torrefaction experimental time. A thermal analyzer is an analysis instrument that simultaneously changes heat flow/temperature gaps and weights over temperature or time in a heating or cooling process with controlled air pressure. It is often used to test the melting point, boiling point, the critical point of solid phase transition, Curie temperature, glass transition temperature, crystallization time, crystallization temperature, crystallization degree, melting heat, reaction heat, etc. It has been widely applied in fields including materials, chemicals, medicine, pharmaceuticals, life, food, and energy.

2. Methods
As biomass torrefaction procedures are complex chemical reactions, results often differ according to changed variables. In addition, various types of biomass characteristics should be overcome in technology and pattern. The potential of torrefaction is to become an important technological range of biomass pretreatment technology and high quality solid fuel. Meanwhile, various types of biomass torrefaction experimental data are not yet complete, and thus, are inadequate. Therefore, this study aimed to discuss the impact of three variables, including heating rate, torrefaction temperature, and torrefaction time in the torrefaction process on the
residual weight percentage and heat value for torrefaction in torrefying Dimocarpus longan using SDT (Simultaneous DSC/DTA-TGA Thermal Analyzer) for Dimocarpus longan torrefaction in an hypoxia environment, in order to provide reference indicators for mass balance and economic analysis of Dimocarpus longan torrefaction design.

3. Expected Results/ Conclusion/ Contribution
The purpose of this study is to investigate the torrefaction behavior of the biomass Dimocarpus longan using TG/DTA thermoanalysis technology. Four different heating rates of 10, 20, 40, and 80 °C/min, five different torrefaction temperatures of 220, 260, 300, 340, and 380 °C, and four torrefaction times of 10, 20, 30, and 40 minutes were considered. The results showed that 398, 415, 597, 815, and 1043 kJ were required, respectively, for torrefying 1 kg of Dimocarpus longan for 40 minutes at 220, 260, 300, 340, and 380 °C. Heating rate is also a factor that could affect the torrefaction process of biomass. When the final torrefaction temperature is 260 °C (30 min), the heat requirements of 1 kg Dimocarpus longan are 167, 284, 375, and 634 kJ at the heating rates of 10, 20, 40, and 80 °C/min, respectively. Under these experimental conditions, the torrefaction temperature of 260 °C at the end temperature, heating rate of 80 °C/min, and 40 min for the best torrefaction also has the maximum heat absorption to provide amplification torrefying reference data.

Keywords: Biomass, Simultaneous DSC/DTA-TGA Thermal Analyzer, torrefaction, Dimocarpus longan
ICCBES-1124

Biomass Gasification in a Bubbling Fluidized Bed

Jung-Chin, Tsai*, Chiao-Sung, Wu and Wan-Ju, Li
Department of Chemical Engineering, Ming Chi University of Technology, Taiwan
E-mail address: jctsai@mail.mcut.edu.tw

1. Background/ Objectives and Goals

Biomass energy, or bio-energy, refers to renewable energy by converting biomass, and is the most available resource on Earth, as it is a value energy product that can replace depleting fossil energy. Biomass mainly consists of cellulose, hemicelluloses, and lignin, with cellulose content about 40~50%, hemicelluloses content about 2~30%, and lignin about 5~20%. After conversion, biomass can be prepared into liquid, gas, and solid fuels. For the increasingly scarce fossil fuels, biomass energy is an important resource.

Kobayashi and Fan (2011) classified biomass applications into thermochemical and biochemical methods. The biochemical method refers to producing high quality gas or liquid fuel through the biochemical action of microorganisms, including Fermentation, Hydrolysis, Anaerobic Digestion, and Biophotolysis. Thermochemical method refers to the conversion of biomass through thermochemical methods, including Combustion, Gasification, Pyrolysis, Liquefaction, and Chemical Looping. Gasification technology is one of methods with the highest efficiency in biomass energy conversion. The produced syngas can be used in many ways, including the synthesis of chemicals, drugs, fuel, and thermo-electric symbiosis.

2. Methods

Biomass gasification is the process to convert biomass into a mixture of combustible gases, such as CO, H2, CH4, and CO2 through partial oxidation. Using gasification media can produce gases of different heating values. When air, or a mixture of water vapor and air, is used as the gasification agent, the produced gas is of low heating value and can be directly burned in boilers, internal combustion engines, and gas turbines. When using oxygen or water vapor as the gasification agent, the produced gas is of medium heating value and can be directly burned or used as the raw material for the production of chemical products, such as methanol, dimethyl ether. When using hydrogen as the gasification agent, the produced gas is of high heating value, and can be directly used as a gas fuel, as well as the raw material for processing chemical products of medium heating value gas.

The purpose of this study is to investigate the biomass gasification to produce the hydrogen and product gas composition in a bubble fluidized bed. Pinus taiwanensis was used as the biomass for experimental to discuss the sensitivity analysis of the two major influencing factors of
model gasification process operations (equivalence ratio (ER) and gasification temperature) regarding product gas composition. The effects of ER (0.2–0.4) and the gasification temperature (600°C–800°C) were studied.

3. Expected Results/ Conclusion/ Contribution
The experimental results found that CO₂ content decreased with rising gasification temperature; however, the H₂ and CO contents increased, while the CH₄ content changed little. In addition, with the rising ER value, the CO, H₂, and CH₄ contents decreased while the CO₂ content increased. The experimental results found that CO₂ content decreased with rising gasification temperature; however, the H₂ and CO contents increased, while the CH₄ content changed little. In addition, with the rising ER value, the CO, H₂, and CH₄ contents decreased while the CO₂ content increased.

References:

Keywords: biomass, gasification, bubbling fluidized bed, Pinus taiwanensis
ICCBES-1127
Preparation of Ni-doped TiO2 Photocatalysts and Their Photocatalytic Properties under Visible Irradiation

Cheewita Suwanchawalit, Apinat Reanpong
Department of Chemistry, Faculty of Science,
Silpakorn University Sanam Chandra Palace Campus, Thailand
E-mail address: suwanchawalit_c@su.ac.th

1. Background/ Objectives and Goals
The heterogeneous photocatalytic process has been extensively utilized to directly mineralize pollutants to CO₂, H₂O and other inorganic ions. Titanium dioxide (TiO₂) has been a promising material for photocatalytic applications due to its stability, non-toxicity, low cost and high oxidative power. TiO₂ is a wide band gap semiconductor that limits the utilization of visible spectrum of solar radiation. The development of sustainable photocatalysts working under visible-light irradiation is a field of great interest. Among several strategies, modifications of TiO₂ by doping have attracted wide attention for enhancing the photocatalytic efficiency. Recently we have prepared Ni-doped TiO₂ photocatalysts through the simple impregnation method. The amount of Ni doping on their microstructure, optical property and photocatalytic activity was investigated.

2. Methods
Ni-doped TiO₂ photocatalysts were prepared through the simple impregnation method. In this study 5, 10, 25 mol% of Ni doping were prepared by mixing a nickel solution with TiO₂ powders via a modified impregnation method. The physical properties of the Ni-doped TiO₂ samples were studied by several techniques such as X-ray powder diffraction (XRD), scanning electron microscopy (SEM), Fourier-transformed infrared spectroscopy (FT-IR), specific surface area by the Brunauer-Emmett-Teller method, and UV-Vis diffuse reflectance spectroscopy (DRS). The photocatalytic properties of Ni-doped TiO₂ samples were evaluated by the degradation of methyl blue under visible light irradiation.

3. Expected Results/ Conclusion/ Contribution
XRD patterns showed that pure TiO₂ sample and Ni-doped TiO₂ samples were anatase phase. No diffraction patterns of Ni peaks were observed. The crystallite size of Ni-doped TiO₂ samples were examined using the Scherrer equation. SEM results revealed that the pure TiO₂ and Ni-doped TiO₂ nanoparticles had coral-like structures. The FT-IR spectra showed the characteristic bands of the titania and hydroxyl groups on the surface of the titania. The DRS spectra revealed that the Ni-doped TiO₂ samples showed the extended absorbance into the visible region. Importantly, the Ni-doped TiO₂ samples exhibited high photocatalytic activity.
degradation of methylene blue solution under visible light irradiation.

Fig. 1 XRD patterns of pure TiO$_2$ and Ni-doped TiO$_2$ samples.

Fig. 2 FT-IR spectra of pure TiO$_2$ and Ni-doped TiO$_2$ samples.
Fig. 3 SEM images and EDS mapping analysis of pure TiO$_2$ and Ni-doped TiO$_2$ samples.
Keywords: Ni-TiO$_2$, nickel-doped TiO$_2$, visible photocatalyst, methylene blue
ICCBES-1128
Long-Term Stability of Dye-Sensitized Cells with Different Dye-Covered TiO2 Electrodes

Fang Chi Chang*, Shun Chi Chen
Department of Chemical Engineering, Ming Chi University of Technology, Taiwan
E-mail address: fangchi1109@gmail.com

Po Tsung Hsiao, Jung Pin Chiu, Yung Liang Tung
Green Energy & Environment Research Laboratories,
Industrial Technology Research Institute, Taiwan.

1. Background
One of attractive reasons for dye-sensitized cells (DSCs) is capable to manufacture colorful appearance by adsorbing different kinds of dyes. However, the short lifetime is always a big issue for commercialized requirements. The interfacial connection between dye molecule and TiO2 surface is believed to a weakest part, which causes efficiency decay. In this study, we choose common commercial dyes, including in Z907, black dye, and D131, for long-term stability test and evaluate the probability of commercializing colorful DSCs.

2. Methods
To prepare the working electrode, the TiO2 paste was deposited using a screen printing technology on a Fluorine-doped tin oxide (FTO) coated glass substrate, followed by annealed at 490 °C for 1 h. The counter electrode was a Pt-coated film, where the Pt paste was also deposited by screen printing on a FTO conducting glass substrate and annealed at 490 °C for 1 h. A 60 μm thick thermoplastic film was used as a sealant to assembly a working electrode and counter electrode into a sandwich structure. A peristaltic pump made dye solution flow slowly and repeatedly inside the cell through pre-drilled holes on the counter electrode to adsorb dye on TiO2 film. Dye adsorption was kept at room temperature and carried out for 24 h. Z907, black dye, and D131 was used as dye solution with a concentration of 0.5 mm. After dye adsorption, acetonitrile flowed inside the cell using the same method to wash out the residual dye molecules. The electrolyte solution, composed of iodine, NMBI, PMII that was dissolved in MPN, was injected into the cell to fill the space between the dye-covered TiO2 electrode and Pt-counter electrode. The pre-drilled holes were sealed by a UV cured glue and a cover glass. Potocurrent-voltage characteristics were performed under an illumination of AM 1.5 spectrum. For long-term stability test, cells were placed in a climate chamber with a high temperature and relative humidity. The temperature and relative humidity were kept at 50 °C and 85%, respectively.
3. Expected Results/ Conclusion/ Contribution

To understand the stability of different kinds of dyes, we observed the changes of photovoltaic properties of different dye sensitized cells under a condition of 50 °C in temperature and 85% in relative humidity, as shown in Figure 1. It showed that the efficiency decay of Z907 sensitized cell was the slowest, followed by Black dye, and D131 was the fastest. The decay of efficiency was mainly resulted from the decrease of current density, which may be related to dye desorption. An amphiphilic dye, Z907, with bipyridyl ligand containing long alkyl chains was hydrophobic to prevent from H₂O attack, thus exhibiting a better stability for the damp heat. After a 1000 hours of stability test, the Z907 and black dye sensitized cells still maintained 80% of efficiency, compared to initial value. However, the efficiency of D131 sensitized cell decay over 20%, due to a severe decrease in open circuit voltage. In addition, lots of black particles appeared on counter electrode for D131 sensitized cell, which may be ascribed to the aggregation of detaching Pt particles. This indicated that the stability of D131 organic dye must be improved in order to manufacture colorful DSCs as commercial products.

Keywords: dye-sensitized solar cell, black dye, Z907, D131, long-term stability
ICCBES-1129
Effect of Carbon Sources on Performance of LiFePO4 Cathode Materials

Tzu-Sheng, Chen, Chia-Hsuan, Li
Department of Chemical Engineering, Ming Chi University of Technology, Taiwan
E-mail address: f904nancy@yahoo.com.tw

Wen-Chen, Chein\textsuperscript{b}
Department of Chemical Engineering, Ming Chi University of Technology, Taiwan
\textsuperscript{b} Battery Research Center of Green Energy, Ming Chi University of Technology, Taiwan
E-mail address: wcchien@mail.mcut.edu.tw

1. Background
Lithium ion battery has attracted much attention as one of the most promising energy storage and power sources for electric vehicles due to its outstanding electrochemical performance, high capacity and energy density compared to conventional rechargeable batteries. Since Padhi and Goodenough and co-workers reported that the olivine-structure lithium iron phosphate (LiFePO\textsubscript{4}, LFP) could be considered as the cathode material for Li-ion batteries due to its low raw materials cost, high safety, and long cycle stability, olive structure LFP has been extensively studied compared with other candidates of cathode materials for lithium ion batteries. However, the poor Li-ions diffusion coefficient and low electronic conductivity of LFP limit its commercial application. In this study, LiFePO\textsubscript{4}/carbon (LFP/C) composite cathode materials were synthesized by the solid-state reaction under H\textsubscript{2}/Ar (2%/98%) atmosphere. Various carbon sources were used as the carbon layer coated on the surface of LFP for the preparation of LFP/C materials, including sucrose, ascorbic acid, salicylic acid, malonic acid, and lauric acid. The effect of carbon sources on the properties and electrochemical performance of LFP/C cathode materials was investigated.

2. Methods
Lithium iron phosphate/carbon (LFP/C) composites were synthesized by solid-state reaction as described below. The raw materials, Li\textsubscript{2}CO\textsubscript{3}, Fe\textsubscript{2}O\textsubscript{3}, H\textsubscript{3}PO\textsubscript{4} and Super P carbon were mixed at a molar ratio of 1:1:1:1 (Li:Fe:P) under 85°C for 2h. The mixture was dried in an oven for 12h. Then, the dried solid mixture was grounded by hand and transferred into a quartz crucible and placed into an oven. LFP powder was synthesized by heating at 600-700°C for 10-20h under 98%Ar+2%H\textsubscript{2} flow. The as-prepared LFP were milled in acetone using a planetary ball mill with ball-to-powder ratio of 3:1 (5mm steel grinding ball), rotating speed of about 250 rpm, and ball-milling time of 3 h. The ground slurry was filtered to remove acetone and re-dispersed in a carbon source (sucrose, ascorbic acid, salicylic acid, malonic acid, and lauric acid) aqueous solution.
The solution was dried at 100°C and then heated at 600-700°C under a 98% Ar+2%H₂ atmosphere for 6-10 h to decompose the carbon source into carbon on the surface of LFP particles and thus form the LFP/C composite cathode materials. Finally, the properties of the prepared LFP/C materials were characterized by different analysis, including the crystal phase and crystalline from X-ray diffraction analyzer (XRD), carbon structure from Raman micro-spectroscopy instrument (Raman), particle shape and size from scanning electron microscopy (SEM), the chemical composition from elemental analysis (EA), and thickness of carbon coating layer from transmittance electron microscopy (TEM), and electrochemical performance from the charge/discharge test, respectively.

3. Conclusion

The XRD patterns reveal that the prepared lithium iron phosphate (LFP) particles have the high crystalline structure with a single phase olivine structure. The average crystallite size calculated using Scherrer’s formula is 30-50 nm. On the other hand, the SEM images show that material consisted of microcrystals that have sizes between 5-20µm. The results show that the nanosized LFP crystallites agglomerate into microsized secondary grains by aggregations. TEM images show that the thickness of carbon coating layer on the surface of LFP was about 2-5nm and quite uniform. The Raman spectra indicate that the ratio of amorphous carbon (D band) and graphite (G band) is in the range of 1.02-2.37, depending on the different carbon sources. The EA and EDS analysis shows that the chemical composition of prepared LFP is very uniform and well corresponding to the experimental design value. This investigation also reveals that the lithium iron phosphate/carbon (LFP/C) cathode materials prepared from sucrose and ascorbic acid have the better material and electrochemical properties than those obtained from salicylic acid, malonic acid, and lauric acid. The best discharge capacity is about 130mAh/g at 0.1C for the LFP/C cathode materials prepared from ascorbic acid.

Keywords: Lithium iron phosphate, Carbon source, Solid phase reaction, Cathode materials, Carbon coating
ICCBES-1152
Histone Deacetylase Inhibition of Minor Phenolic Compounds from Zingiber Officinale and Molecular Docking Stud

Pakit Kumboonma
Natural Products Research Unit, Center for Innovation in Chemistry, Department of Chemistry, Faculty of Science, Khon Kaen University, Thailand
E-mail address: iamkumboonma@gmail.com

Chanokbhorn Phaosiri
Natural Products Research Unit, Center for Innovation in Chemistry, Department of Chemistry, Faculty of Science, Khon Kaen University, Thailand
chapha@kku.ac.th

Chavi Yenjai
Natural Products Research Unit, Center for Innovation in Chemistry, Department of Chemistry, Faculty of Science, Khon Kaen University, Thailand
chayen@kku.ac.th

Thanaset Senawong, Somprasong Saenglee
Natural Products Research Unit, Department of Biochemistry, Faculty of Science, Khon Kaen University, Thailand
E-mail address: sthanaset@kku.ac.th

Somprasong Saenglee
Natural Products Research Unit, Department of Biochemistry, Faculty of Science, Khon Kaen University, Thailand
bird_scorpio@hotmail.com

Khatcharin Siriwong
Materials Chemistry Research Center, Department of Chemistry, Faculty of Science, Khon Kaen University, Thailand
E-mail address: skhatcha@kku.ac.th

1. Background/ Objectives and Goals
Histone deacetylase (HDACs) are epigenetic targets with important roles in cancer, inflammation, neurodegeneration, and metabolic disorders. Herbal drugs have played a dominant role for treatment a board spectrum of diseases. We have focused on the phytochemicals from ginger (Zingiber officinale) to investigate their anticancer activities based
on histone deacetylase inhibitory activities.

2. Methods

The rhizomes of ginger were chopped into pieces, dried under shade, and grounded into coarse powders. The resulting materials were extracted with CH$_2$Cl$_2$ to give a residue. The residue was further subjected to column chromatography (CC) on silica gel and eluted with increasing polarity of elution solvent system (hexane and EtOAc) to obtain [6]-gingerdione (1), 1-dehydro-[6]-gingerdione (2) and [6]-gingerdiol (3). These compounds were evaluated as HDAC inhibitors via in vitro fluorometric assay. Molecular docking experiments were conducted on the compounds with the HDAC2, HDAC4, HDAC7 and HDAC8 enzymes.

3. Expected Results/ Conclusion/ Contribution

The minor phenolic compounds from ginger, [6]-gingerdione (1), 1-dehydro-[6]-gingerdione (2) and [6]-gingerdiol (3), were isolated and evaluated as HDAC inhibitors. All compound exhibited inhibitory activity against HDACs in the micromolar concentration ranges. Compound 2 was the best HDAC inhibitor among the tested compounds with IC$_{50}$ value as 42 µM. Molecular docking data showed consistent results to the in vitro experiments with the high selectivity with HDAC2 and HDAC7. Further investigation in a cellular level will provide more details for being potential anticancer candidates of these compounds.

Keywords: Ginger, Zingiber officinale, Histone Deacetylase, HeLa cell, Anticancer.
Chemical Composition and Biological Activities of Essential Oil from Fine Scrap and Short Stem Virginia and Burley Tobacco (Nicotiana Tabacum L.)

Chatchanok Sansri  
Faculty of Science, Department of Chemistry, Chiang Mai University, Thailand  
E-mail address: chatchanok_np@hotmail.com

Aphiwat Teerawutgulrag  
Faculty of Science, Department of Chemistry, Chiang Mai University, Thailand  
E-mail address: aphiwattee@yahoo.co.uk

Jiraporn Kulsarin  
Faculty of Agriculture, Department of Entomology, Chiang Mai University, Thailand  
E-mail address: j.tayuti@gmail.com

Background  
In Thailand, tobacco types Virginia and Burley are used as raw material in the manufacture of cigarettes. In the process, fine scrap and short stem are an unavoidable waste. Therefore, study of the chemical composition and biological activities of these waste can lead to utility of them.

Methods  
Extraction of Essential Oil  
The essential oils from fine scrap and short stem types Virginia and Burley tobacco were extracted using hydro-distillation. Each sample (200 g) were suspended in a Clevenger-type apparatus with 2 L of water and distilled for 5 hours. The isolated oil was collected from the graduated receiver. For the removal of water from the oil, the extract was treated with anhydrous sodium sulfate. The oil samples were stored under nitrogen gas in sealed vials in a refrigerator until used for analysis and biological activities test.

Analysis of Essential Oil  
Essential oils were analyzed by GC-MS using a 7890A Agilent gas chromatography coupled to a 5975C (EI) Agilent mass spectrometer with HP-5MS column. The identification of each compound were assigned by comparison of mass spectra database such as NIST05.L (National Institute of Standards and Technology) and WILEY275 (Wiley, New York, USA) were also used for spectral matching and Kovats indices with previous literature.

Determination of Antimicrobial Activity  
The essential oil were tested against standard Staphylococcus aureus and Escherichia coli
bacterial strains using paper disc diffusion method. The bacterial suspensions were adjusted to 0.5 McFarland standard and 100 µl of these were swabbed on the TSA medium using a sterilized cotton bud. Then, sterilized filter paper discs (6 mm diameter, Whatman No.4) were impregnated with 10 µl of the sample at different concentrations and placed on the surface of TSA covered with tested bacterial strain, respectively. DI water was used as negative control while amoxicillin as positive control. Then, the plates were incubated at 37 degree Celsius for 24 hours. Antibacterial activity was investigated by measuring the zones of inhibition (mm). All tests were carried out for three replications and the results were averaged.

Results and Discussion

Chemical Composition of the Essential Oil
The essential oils from fine scrap and short stem types Virginia and Burley tobacco were obtained by hydro-distillation of an air dried sample with a yield of 0.04, 0.02, 0.01 and 0.02% (w/w). The constituent and their relative content in the essential oils were analyzed by GC-MS and Kovats indices. The main component of each sample is shown in the table.

<table>
<thead>
<tr>
<th>Sample</th>
<th>Major component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Virginia fine scrap</td>
<td>1-methoxy-4-(1-propenyl)benzene</td>
</tr>
<tr>
<td>Virginia short stem</td>
<td>4-methylene-1-methyl-2-(2-methyl-1-propen-1-y1)-1-vinyl</td>
</tr>
<tr>
<td>Burley fine scrap</td>
<td>3-(4,8,12-Trimethyltridecyl) furan</td>
</tr>
<tr>
<td>Burley short stem</td>
<td>1-methoxy-4-(1-propenyl)benzene</td>
</tr>
</tbody>
</table>

Antimicrobial Activity
The essential oil from fine scrap and short stem types Burley showed greater activities to inhibit the growth of *Staphylococcus aureus* and *Escherichia coli* than the oil from the fine scrap and short stem types Virginia. However, all of them has lower activity than amoxicillin.

<table>
<thead>
<tr>
<th>Bacteria</th>
<th>Inhibition zone (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Virginia</td>
</tr>
<tr>
<td></td>
<td>fine scrap</td>
</tr>
<tr>
<td><em>S. aureus</em></td>
<td></td>
</tr>
<tr>
<td>fine scrap</td>
<td>10.0±1.00</td>
</tr>
<tr>
<td>short stem</td>
<td></td>
</tr>
<tr>
<td><em>E. coli</em></td>
<td></td>
</tr>
<tr>
<td>fine scrap</td>
<td>8.5±1.00</td>
</tr>
<tr>
<td>short stem</td>
<td></td>
</tr>
</tbody>
</table>

References
2. Xianzhong Z., Hongjian G., Lifen Z., Donghong L. and Xingqian Ye. (2012) “Extraction of essential oil from discarded tobacco leaves by solvent extraction and steam distillation, and identification of its chemical composition” Industrial Crops and Products., 39:

ICCBES-1158

Synthesis of Diamondback Moth (Plutella Xylostella (L.)) Sex Pheromone

Aphiwat Teerawutgulrag, * Rachaneebhorn Inkum, Wipanoot Baison
Department of Chemistry, Faculty of Science, Chiang Mai University, Thailand
E-mail address: aphiwattee@yahoo.co.uk

Jiraporn Kulsarin
Department of Entomology, Faculty of Agriculture, Chiang Mai University, Thailand

Background
Dimondback moth (Plutella xylostella (L.), DBM) is one of the insect which destroys various kinds of vegetable, especially cabbage.1-3 In order to control the damage and avoiding usage of insecticide, trapping DBM with sex pheromone was an alternative method.4 A chemical found in the pheromone is Z-11-hexadecenal and synthesis method was reported.5 However, this aldehyde is unstable in the air. Therefore, freshly prepared aldehyde via a simple pathways and stable chemical is a desired route to make pheromone in short period.

Methods
All compounds were identified with chromatographic and spectroscopic methods.

Phosphonium Salt (2)
The solution of 11-bromodecanoic acid 1 (1.04 g, 3.92 mmol) and triphenylphosphine (1.13 g, 4.31 mmol) in toluene (10 mL) was refluxed for 24 h. After the reaction complete, the mixture was cooled to room temperature and concentrated under reduced pressure. The residue was added with dichloromethane (10 mL) then the solid product was filtrated and washed with toluene gave phosphonium salt (2.03 g, 98 %) as a pale yellow solid and was used in the next step without purification.

Z-11-Hexadecenoic Acid (4)
A suspension of phosphonium salt 2 (2.16 g, 4.01 mmol) in THF (100 mL) was added potassium t-butoxide (0.90 g, 8.02 mmol) at 0 °C and stirred at room temperature for 1 h. Then pentanal 3 (0.32 g, 3.76 mmol) was added dropwise. After the reaction was completed, water (5 mL) was added and concentrated under reduced pressure. The crude mixture was purified by column chromatography (5% ethyl acetate-hexane) gave Z-11-hexadecenoic acid (0.32 g, 41 %) as a colorless oil.

Z-11-Hexadecenol (5)
Lithiumaluminium hydride (0.045 g, 1.21 mmol) was added to a solution of Z-11-hexadecenoic
acid (0.20 g, 0.80 mmol) in THF(2 mL) at 0 °C. After 4 h, water (2 mL) was added. The resulting crude was extracted with ethyl acetate (3x10 mL). The obtained layer was evaporated to dryness. Purification by column chromatography (5% ethylacetate-hexane) gave Z-11-hexadecenol (0.16 g, 85 %) as a colorless oil.

Z-11-Hexadecenal (6)
PCC (0.09 g, 0.44 mmol) was added to Z-11-hexadecenol (0.07 g, 0.29 mmol) in dichloromethane (2 mL) at 0 °C. After completion, the mixture was filtered and concentrated under reduced pressure. The crude mixture was purified by column chromatography (5% ethyl acetate-hexane) gave Z-11-hexadecenal (0.06 g, 83 %) as a colorless oil.

Results and Discussion
Treatment of 11-bromodecanoic acid with triphenylphosphine in THF gave phosphonium salt with 98 % yield. After Wittig reaction with pentanal, Z-11-hexadecenoic acid was obtained in 41%. Reduction with LAH yielded Z-11-hexadecenol in 85 %. This stable alcohol could be kept at low temperature for a long time. Oxidation of Z-11-hexadecenol with PCC yielded Z-11-hexadecenal with 83%. The overall yield was 28% over 4 steps.

Z-11-Hexadecenoic Acid (4)
IR (neat), $\nu_{\text{max}}$ 2926, 1710; $^1$H-NMR (400 MHZ , CDCl$_3$) 1.43 (9H, s), 3.66-3.78 (2H, m), 4.54-4.72 (1H, br), 5.05-5.20 (2H, m), 5.76-5.88 (1H, m); $^{13}$C-NMR (100 MHZ, CDCl$_3$) 155.8, 134.9, 115.6, 79.3, 43.0, 28.4; HRMS calcd for C$_8$H$_{15}$NO$_2$ [M+ Na]$^+$ 180.1000, found 180.0997.

Z-11-Hexadecenol (5)
IR (neat), $\nu_{\text{max}}$ 3329, 2925, 1460, 1056; $^1$H-NMR (400 MHZ, CDCl$_3$) 0.84-0.97 (3H, m), 1.24-1.40 (18H, m), 1.49-1.61 (2H, m), 1.92-2.11 (4H, m), 3.57-3.65 (2H, m), 5.31-5.37 (2H, m); $^{13}$C-NMR (100 MHZ, CDCl$_3$) 129.8, 129.7, 62.9, 32.7, 31.9, 29.7, 29.5, 29.5, 29.4, 29.3, 29.2, 27.1, 26.8, 25.7, 22.2, 13.9; HRMS calcd for C$_{16}$H$_{33}$O [M+1]$^+$ 241.2531, found 241.2527.

Z-11-Hexadecenal (6)
IR (neat), $\nu_{\text{max}}$ 3329, 2925, 1460, 1056; $^1$H-NMR (400 MHZ, CDCl$_3$) 0.84-0.95 (3H, m), 1.21-1.39 (16H, m), 1.57-1.67 (2H, m), 1.93-2.07 (4H, m), 2.37-2.45 (2H, m), 5.30-5.40 (2H, m), 9.75 (1H, s); $^{13}$C-NMR (100 MHZ, CDCl$_3$) 202.8, 129.8, 129.7, 43.8, 31.9, 29.6, 29.4, 29.3, 29.2, 29.2, 29.1, 27.1, 26.8, 22.3, 22.0, 13.9; HRMS calcd for C$_{16}$H$_{33}$O [M+1]$^+$ 239.2375, found 239.2390.

References
ICCBES-1162

Study on the Synthesis of Styrenated Phenol Using Organometallic Catalysts

Seokhwan Son, Seungmin Lee
Department of Chemical Engineering, Sunchon National University, Korea
sonsh@sunchon.ac.kr

Hyunjun Yun
Department of Chemical Engineering, Sunchon National University, Korea
kissme0022@naver.com

Hogeun Ahn
Department of Chemical Engineering, Sunchon National University, Korea
hgahn@sunchon.ac.kr

Minchul Chung *
Department of Chemical Engineering, Sunchon National University, Korea
mchung@sunchon.ac.kr

Wonbong Kwak
SFC. Co., Ltd., Korea
skysub3@naver.com

Sunghun Jung
SFC. Co., Ltd., Korea
saint@isfc.co.kr

Abstract
The oxidation of rubbers and resins are one of the most important problems in the field because the absorption of a small amount of oxygen causes considerable changes in the physical and mechanical properties. Such changes can be retarded, but not completely overcome by the addition of antioxidants. The most common antioxidants are derivatives of aromatic amines and phenols. Phenol antioxidants are effective stabilizers providing excellent long-term heat stability by preventing thermo-oxidative degradation process and service life. Typical phenolic antioxidants occur in the shape of styrenated phenol that substitution reaction of hydrogen of phenol by alkylation of styrene. Synthesis of styrenated phenol is used Bronsted acid and Lewis acid by the catalyst. These acids will lead to discoloration of the styrenated phenol remaining in the product. In addition, composition ratio of compound that is produced has problems due to source material and amount of catalyst.
In this study, styrenated phenols of monomer, dimer, and trimer products were synthesized for increasing selectively. Di-styrenated phenol (DSP) from the configuration of the styrenated phenol were synthesized. Suzuki–Miyaura coupling is one of the most used coupling reactions for carbon–carbon bond formation, mostly due to the wide variety and accessibility of the starting materials, as well as the mild reaction conditions used. Therefore, DSP synthesis in the Suzuki-Miyaura coupling was used. These styrenated phenol were analyzed using a MS, FT-IR, $^1$H($^{13}$C)-NMR, and GC.

Keywords: Styrenated Phenol, Antioxidant, Selectivity

1. Background
The oxidation of rubbers and resins are one of the most important problems in the field because the absorption of a small amount of oxygen causes considerable changes in the physical and mechanical properties. Such changes can be retarded, but not completely overcome by the addition of antioxidants. The most common antioxidants are derivatives of aromatic amines and phenols. Phenol antioxidants are effective stabilizers providing excellent longterm heat stability by preventing thermo-oxidative degradation process and service life. Typical phenolic antioxidants occur in the shape of styrenated phenol that substitution reaction of hydrogen of phenol by alkylation of styrene. Synthesis of styrenated phenol is used Bronsted acid and Lewis acid by the catalyst. These acids will lead to discoloration of the styrenated phenol remaining in the product. In addition, composition ratio of compound that is produced has problems due to source material and amount of catalyst.

2. Methods
A synthetic strategy for the synthesis of compound 3 is outlined in Fig. 1.
2.1 General Considerations

For this experiment, N,N-diisopropylamine, N-bromosuccinimide and (1-bromoethyl)-benzene were purchased from Alfa Aesar. (1-bromoethyl) benzene was stored at a low temperature. Phenol, Butyllithium and Trimethyl borate was purchased from Aldrich. Pd(PPh$_3$)$_4$ were purchased from Tokyo Chemical Industries (TCI). K$_2$CO$_3$, MgSO$_4$, CH$_2$Cl$_2$, HCl, THF, EtOH and Hexane were purchased from Deajung. All solvents were purified using the method of purification specified in Laboratory Chemicals (Third Edition) by D.D. Perrin and W. L. F. Armarego. All syntheses were performed using a Schlenk tube under an argon atmosphere. Analytical thin-layer chromatography (TLC) was performed on Merck Aluminin oxide-aluminum plates with F-254 indicator, visualized by irradiation with UV light. Column chromatography was performed using s Aluminin oxide Merck 90 (particle size 0.063–0.200 mm). In addition, deuterated CD$_3$OD and CDCl$_3$ were used as the solvents $^1$H($^{13}$C)-NMR. The $^1$H($^{13}$C)-NMR spectra were determined using a Bruker AVANCE 400 FT-NMR spectrometer (1H, 400MHz). A Jasco 600 series FT/IR Spectrometer(FT/IR-6600) was used for the FT-IR spectrum analysis. The Mass spectroscopy was carried out using the MALDI-TOF MS (ABI 4700, Bruker Ultraflex III) at the Korea Basic Science Institute (KBSI). The analytical conditions were as follows: scan range, m/z 150-1500; positive spray voltage, +3.0kV detector voltage, 1.65kV; simmer voltage, 9.0V; pressure of TOF region, 1.5×10-4 Pa, and temperature, 40°C; ion source temperature, 200°C; trap cooling gas(Ar) flow rate, 94mL/min; ion trap pressure, 1.8×10-2 Pa; collision gas(Ar) flow rate, 43mL/min; ion accumulation time, 10ms; precursor ion selected width, 3.0 m/z units, and the selected time, 20ms. MS data was acquired by using the data-dependent function. Reactant and product mixture analyzed by using the gas chromatography (HP-6890, Hewlett-Packard) with a flame ionization detector, in which

![Chemical structures](image)
capillary column, HP-5 (30m * Φ0.32mm 0.25μm). Table 1 shows the operation conditions of GC in this study.

<table>
<thead>
<tr>
<th>Table 1: Operation conditions of GC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gas chromatograph</strong></td>
</tr>
<tr>
<td><strong>Sampling</strong></td>
</tr>
<tr>
<td><strong>Carrier gas &amp; Flow rate</strong></td>
</tr>
<tr>
<td><strong>Column</strong></td>
</tr>
<tr>
<td><strong>Oven temperature</strong></td>
</tr>
<tr>
<td><strong>Injection temperature</strong></td>
</tr>
<tr>
<td><strong>Detector</strong></td>
</tr>
<tr>
<td><strong>Detector Temperature</strong></td>
</tr>
<tr>
<td><strong>Air &amp; H₂ flow rate</strong></td>
</tr>
<tr>
<td><strong>Split rate</strong></td>
</tr>
</tbody>
</table>

### 2.2 Synthesis of 2,6-Dibromophenol (1a)

To a solution of phenol (1.5 g, 16 mmol) in dichloromethane (10 mL) was added a solution of N,N-diisopropylamine (0.44 mL, 3.1 mmol). To this mixture was added a solution of N-bromosuccinimide (5.7 g, 32 mmol) in dichloromethane (150 mL), dropwise over 3 h. After stirring for 1 h at room temperature, aqueous hydrochloric acid (1 M) was added until the solution became acidic. The organic layer was washed with water (80 mL), dried over sodium sulfate and concentrated in vacuo to produce a colourless residue. The resultant residue was purified by flash column chromatography using hexanes as eluent, affording the title compound (1a) as colorless crystals. (Yield: 72%)

\[ ^1\text{H-NMR} \ (400 \text{ MHz, } \text{CDCl}_3) \delta: 5.88 \ (s, 1H), 6.70 \ (t, 1H, J = 8 \text{ Hz}), 7.45 \ (d, 2H, J = 8.4 \text{ Hz}); ^{13}\text{C-NMR} \ (400 \text{ MHz, } \text{CDCl}_3) \delta: 111.0, 122.5, 132.1, 149.5; \] the 1H and 13C NMR data obtained were in agreement with that reported in the literature (Fan, G. & Zhang, H. 2008, p6080.). FT-IR(KBr, cm\(^{-1}\)) : 3419.98, 1439.00, 1333.92, 1238.03, 1135.23, 757.65, 707.56(C-Br)

### 2.3 Synthesis of Bisboronic Acids (2)

Butyl-lithium (1.6M in hexanes, 4.43mmol) was added, dropwise, via syringe to a stirred solution of the starting 2,6-dibromophenol (0.5mg, 2.011mmol) in THF (20 mL) in a dry ice-acetone cold temperature bath.
After the mixture was stirred for 30 min in the cold bath, a solution of trimethyl borate (1.254g, 12.066mmol) was added. After the mixture was stirred in the cold bath for 30 min, the reaction mixture was stirred at ambient temperature for 1h. The reaction mixture was quenched with 30mL of 10% HCl. The product was extracted with CH$_2$Cl$_2$. The product was dried with MgSO$_4$. After dry yield the pure product. (Yield: 58%)

$^1$H-NMR (400 MHz, CDCl$_3$) δ: 7.11 (t, 1H), 7.71 (d, 2H); FT-IR(KBr, cm$^{-1}$) : 3382.43, 1603.13, 1273.60(B-O), 749.64

2.4 Synthesis of Di-Styrenated Phenol (3)

A degassed solution of K$_2$CO$_3$ (799 mg, 5.788mmol) in H$_2$O (3ml), ethanol (2ml), and THF(28 ml) was added to a flask containing (1-bromoethyl)benzene (535mg, 2.89mmol), bisboronic acid (263mg, 1.44mmol) and Pd(PPh$_3$)$_4$ (92mg, 0.0804mmol) in argon gas. The mixture was refluxed for 48hr. The solvent was removed in a vacuum and the residue was dissolved in CH$_2$Cl$_2$, washed with a saturated NaCl solution (50mL), and dried over MgSO$_4$. The solution was concentrated and MeOH was added, resulting in the precipitation of a white powder from the brown solution. The resultant residue was purified by column chromatography using hexanes as eluent afforded the title compound(3). (Yield: 77%)

$^1$H-NMR (400 MHz, MeOD) δ: 6.78~7.19 (m, 13H), 4.53 (m, 1H, J = 8 Hz), 3.93 (m, 2H, J = 7.2 Hz), 1.41 (m, 6H, J = 8.8 Hz); $^{13}$C-NMR(400 MHz, MeOD) δ: 21.78, 39.63, 121.41, 125.73, 126.66, 129.08, 135.17, 147.50, 148.34, 150.33; FT-IR(KBr, cm$^{-1}$) : 3445.23(O-H), 1644.60, 1437.23(aromatic ring C-C stretch), 1120.06

3. Results and Discussion

Were synthesized DSP by using a Suzuki-Miyaura coupling using a 2,6-Dibromophenol. The first was a brominated phenol. In this case, 2,6-dibromophenol(1a) are synthesized. The compounds 1a are colorless crystals. The compound 3 are crude yellow liquid. The structure of the synthesized compound was analyzed using $^1$H ($^{13}$C) -NMR. Because all of the products include the same skeleton structure, similar spectra between 7.0 ppm and 9.0 ppm from the peak of aromatic proton were observed. We were unable to obtain the $^{13}$C-NMR data for compounds 2 because their solubility was very. The compound 3 that are measured at $^1$H and $^{13}$C-NMR are shown in Fig. 2.
The mass spectra of 1a and 1b that are measured at ESI-TOF MS are shown in Fig. 4. In the mass spectrum, the peak of complex 1a and 1b was observed at 273.398 and 326.453 m/z.

The FT-IR spectra of 1a are shown in Fig. 5. The IR spectra of 1a shows additional peaks at 3200 cm⁻¹ - 3500 cm⁻¹ due to the presence of -OH stretching, 1585 cm⁻¹ - 1600 cm⁻¹ corresponds to aromatic ring and 850 cm⁻¹ - 515 cm⁻¹ due to the presence of C-Br stretching. This confirms the chemical binding of phenol to bromo.
The FT-IR spectra of 1a are shown in Fig. 6. The IR spectra of 1a shows additional peaks at 3382.43 cm\(^{-1}\) due to the presence of -OH stretching, 1437.23 cm\(^{-1}\) corresponds to aromatic ring. This confirms the chemical binding of compound 3.
It was GC measurement of the compounds of the SP that are sold in Kumho Petrochemical. (fig. 7-a) MSP, DSP and TSP was measured at 8~9.5, 13~14, and 17~18. It was possible to confirm that the single peak emerges from 13.8 at the GC measurement of the synthesized samples. (fig. 7-b) Synthesized DSP demonstrates a single sharp peak, indicating isomers to not be present.

4. Conclusion
In this study, Suzuki coupling was used to compose DSP among SP compound on-ly. Phenol was synthesized 2,6-dibromo phenol by bromide. This is By replacing the bromine at the borate, It was synthesized DSP 1- bromoethlbenzene and Pd (0) using the catalyst. Synthesis yield of Compound 1 is 72%, Compound 2 was 58%, DSP yield is 77%. NMR for synthesized DSP structural confirmation, and the structural analysis using FT-IR DSP at GC measurement of sample of SP compound is seen peak in 13~14, Synthesized DSP, the peak has been confirmed at 13.8. The results of the study were seen presents experimental materials for the selective synthesis of SP compounds.
5. Acknowledgements

This work was supported by the Human Resource Training Program for Regional Innovation and Creativity through the Ministry of Education and National Research Foundation of Korea(NRF-2014H1C1A1066844).

References

Scott, G. Atmospheric Oxidation and Antioxidants; Elsevier: Amsterdam, 1965; p 16.
ICCBES-1165
Preparation of Styrenated Phenol by Alkylation of Phenol with Styrene over H$_2$SO$_4$-Treated M$_x$O$_y$ Catalysts

Hyeonjun Yun
Department of Chemical Engineering, Sunchon National University, South Korea
E-mail address: yhj5356@hanmir.com

Yeongho Lee
Department of Chemical Engineering, Sunchon National University, South Korea
jangho5520@gmail.com

Jangho Cho
Department of Chemical Engineering, Sunchon National University, South Korea
foxmate@naver.com

Seokwhan Son
Department of Chemical Engineering, Sunchon National University, South Korea
sonsh@sunchon.ac.kr

Minchul Chung
Department of Chemical Engineering, Sunchon National University, South Korea
mchung@sunchon.ac.kr

Ho-Geun Ahn*
Department of Chemical Engineering, Sunchon National University, South Korea
hgahn@sunchon.ac.kr

Eun Ju Shin
Department of Chemistry, Sunchon National University, South Korea
E-mail address: ejs@sunchon.ac.kr

Sunghun Jung, Wonbong Kwak
SFC. Co., Ltd., South Korea
E-mail address: skysub3@naver.com

Wonbong Kwak
SFC. Co., Ltd., South Korea
saint@isfc.co.kr
Surfactants are an important raw material of the developing solution for LCD panel. Styrenated phenol in styrenated phenol alkoxylate is a hydrophobic group. Styrenated phenols are usually synthesized by the reaction of styrene and phenol under acid catalysts, and the main products are mixture of mono-styrenated phenol (MSP), di-styrenated phenol (DSP) and tri-styrenated phenol (TSP). Homogeneous catalyst has mainly used in styrenated phenol synthesis, which has a problem such as the difficult of separation of the catalyst from the products. In this study, styrenated phenol (SP) involving high content of di-styrenated phenol (DSP) was synthesized, which can be used to prepare styrenated phenol alkoxylate. The solid catalyst was prepared by impregnation method. $\text{SO}_4^{2-}$ on $\text{SO}_4^{2-}/\text{M}_x\text{O}_y$ catalyst was introduced from an aqueous 1M-$\text{H}_2\text{SO}_4$ solution. The prepared catalyst was dried at 110°C for 12hr, and was calcined for 2hr at 600°C under air atmosphere. The catalysts were characterized by SEM images, BET surface area, X-ray diffraction patterns, and FT-IR spectra. The catalytic activity was examined by measuring the conversion of phenol and styrene in a batch liquid-phase reactor. The concentration of phenol, styrene, and styrenated phenols were measured by GC with capillary column. Almost 100% conversion of both phenol and styrene over 5-$\text{SO}_4^{2-}/\text{TiO}_2$ catalyst were obtained at 5wt% amount of catalyst to the reactants, reaction temperature of 100°C, and reaction time of 1hr. At same reaction conditions, selectivity of MSP, DSP, and TSP were 16.7%, 66.1%, and 17.1%, respectively. On the other hand, almost 100% conversion of both phenol and styrene over 15-$\text{SO}_4^{2-}/\text{ZrO}_2$ catalyst were obtained at 15wt% of amount of catalyst to the reactants at reaction temperature of 100°C, and reaction time of 6hr. At same reaction conditions, selectivity of MSP, DSP, and TSP were 23.6%, 52.1%, and 5.4%, respectively.

Keywords: Styrenated phenols, Alkylation, Solid acid catalyst, $\text{SO}_4^{2-}/\text{M}_x\text{O}_y$

1. Introduction

Synthetic rubber and the resin are widely used in the chemical industry as well as daily life due to their excellent chemical and physical properties. Additives are normally added into the raw materials to improve the oxidative stability. Among the antioxidant, phenolic antioxidant, such as styrenated phenols, have excellent heat stability, non-staining, non-discoloring, and non-migratory.\textsuperscript{1} Furthermore, styrenated phenol and alkoxylate can be used to produce the styrenated phenol alkoxylate, non-ionic surfactant, which is an important raw material, particularly for application in the liquid crystal display panel of color filter, and thin film transistor. Styrenated phenols are usually synthesized by the reaction of styrene monomer and phenol under homogeneous protonic acid and lewis acid catalysts, and the main products are mixture of mono-styrenated phenol (MSP), di-styrenated phenol (DSP), and tri-styrenated phenol (TSP).

However, such catalysts would not be re-useful and hard to separate those from reactants.
Therefore, solid acid catalyst is considered as an alternating catalyst. One of the good candidate acid catalysts is to use the zirconium oxide (ZrO₂) because they have an excellent heat-resistant, corrosion-resistant, low thermal conductivity, chemical stability, and frictional resistance. ZrO₂ is well known to be a highly active catalyst for the C-H bond cleavage of a methyl group. For example, the activity is higher than that of a strong acidic or basic catalyst such as SiO₂-Al₂O₃, H-ZSM-5 for the acylation of chlorobenzene with o-chlorobenzoyl chloride.² Another good candidate acid catalyst is titanium oxide (TiO₂). TiO₂ is one of the most chemically stable, environmentally compatible, and functionally versatile oxide materials. TiO₂ is well known to be a highly active catalyst for the alkylation of benzene with propylene.³ Acidity of the ZrO₂ and TiO₂ can also be controlled by adding a small amount of sulfate ion (SO₄²⁻). Therefore, we investigated the synthesis of styrenated phenols over the SO₄²⁻/ZrO₂ and SO₄²⁻/TiO₂ catalysts under various reaction conditions.

2. Experimental

2.1. Catalyst Preparation
Heterogeneous SO₄²⁻/ZrO₂ and SO₄²⁻/TiO₂ catalyst was prepared by the impregnation method. MₓOᵧ powder was put into an aqueous 1M-H₂SO₄ solution, then dried at 110°C for 12 hr, and calcined for 2 hr at 600°C under air atmosphere.⁴ The prepared catalysts were denoted as X-SO₄²⁻/MₓOᵧ, where X represent the used amount of 1M-H₂SO₄ solution for treating the surface of MₓOᵧ as weight % of SO₄²⁻ to MₓOᵧ. The prepared SO₄²⁻/MₓOᵧ catalysts were characterized by scanning electron microscope (SEM, S-4800, Hitachi), X-ray diffraction (XRD, X`Pert³ MRD, PANalytical), and Fourier transform infrared spectra (FT-IR, Nicolet™ iS™ 10, Thermo Scientific).

2.2 Catalytic Activity
Catalytic activities were tested for styrenated phenol synthesis using a liquid-phase batch reactor maintained inert atmosphere. 10g of phenol was put into a reactor and then catalyst was added in the reactor with stirring, subsequently styrene was introduced by a syringe pump. Total amount of catalyst to the reactants were adjusted in range of 0~30 wt%. Reactant and product mixture were analyzed by using the gas chromatography (HP-6890, Hewlett-Packard) with a flame ionization detector.

3. Results and Discussion

3.1. ZrO₂ Catalysts
3.1.1. Characterization of SO₄²⁻/ZrO₂ Catalysts
Figs. 1 and 2 show the SEM images and XRD patterns of pure ZrO₂ and SO₄²⁻/ZrO₂ catalysts treated with different amount of 1M-H₂SO₄ solution, respectively. No surface changes are observed before and after introducing SO₄²⁻ on ZrO₂. Crystallinity is also maintained to that of pure ZrO₂ without peak shift. These results indicate that introducing SO₄²⁻ on ZrO₂ support
does not affect their original physical properties, which is due to an ionic sulfate.

Fig. 3 shows the FT-IR spectra of pure ZrO₂ and SO₄²⁻/ZrO₂ catalysts treated with different amount of 1M-H₂SO₄ solution and calcination temperature, respectively. The FT-IR analysis in the finger print region showed the presence of 995 cm⁻¹ peak due to the symmetric vibrations of S-O whereas 1041, 1141 and 1236 cm⁻¹ peaks were observed due to the asymmetric vibrations of O-S-O bonds. The 1236 cm⁻¹ peak was increased with increasing the used amount of 1M-H₂SO₄ solution and calcination temperature.

![Fig. 1. SEM images of SO₄²⁻/ZrO₂ catalysts. (A) Pure ZrO₂, (B) 5-SO₄²⁻/ZrO₂, (C) 10-SO₄²⁻/ZrO₂, and (D) 15-SO₄²⁻/ZrO₂ (Scale bar: 5μm)](image-url)
3.1.2. Effect of Amount of Catalyst

Fig. 4 shows the effect of catalyst amount in the range of 0~30 wt% on conversions of phenol and styrene and selectivities of styrenated phenols. The conversion is increased when increasing the catalyst amounts. 100% of conversions were observed and maintained when over 15wt% of catalyst was used (Fig. 4A).
With increasing the amount of catalyst, DSP selectivity was increased, while MSP selectivity was decreased. Generally, selectivity of TSP has not shown to be preferred reaction over $\text{SO}_4^{2-}/\text{ZrO}_2$ catalyst. It is found that the selectivities for three products were kept at over at 15wt% of catalyst amount.

![Graph A](image1.png)

![Graph B](image2.png)

**Fig. 4.** Effect of amount of catalyst on (A) conversions and (B) selectivities at 100°C over $\text{SO}_4^{2-}/\text{ZrO}_2$ catalyst. (Reaction time: 6hr)

### 3.1.3. Effect of Reaction Temperature

Fig. 5 shows the effect of the reaction temperature (50 ~ 140°C) on conversions and selectivities. Increased conversion of phenol and styrene is observed, when reaction temperature increased. The catalyst shows 100% of conversion at over 80°C. $\text{SO}_4^{2-}/\text{ZrO}_2$ catalyst shows a negligible effect on both conversion and selectivity at tested temperatures. With increasing reaction temperature, DSP selectivity was increased, while MSP selectivity was decreased. Selectivity of TSP was independent of reaction temperature.

![Graph A](image3.png)

![Graph B](image4.png)

**Fig. 5.** Effect of reaction temperature on (A) conversions and (B) selectivities over $\text{SO}_4^{2-}/\text{ZrO}_2$ catalyst. (Amount of catalyst: 15wt% to reactants, reaction time: 6hr)

### 3.1.4. Effect of Amount of 1M-$\text{H}_2\text{SO}_4$ Solution

Fig. 6 shows effect of amount of 1M-$\text{H}_2\text{SO}_4$ solution on conversions and selectivities. The conversions of phenol and styrene were almost 100% over all catalysts. With increasing
amount of 1M-H₂SO₄ solution, the selectivities of DSP and TSP were increased a little, while MSP selectivity was decreased. The highest selectivity of DSP was obtained over 15-SO₄²⁻/ZrO₂ catalyst.

3.2. SO₄²⁻/TiO₂ Catalysts

3.2.1. Characterization of SO₄²⁻/TiO₂ Catalysts

Fig. 7 shows SEM images of SO₄²⁻/TiO₂ catalysts treated with different amount of 1M-H₂SO₄ solution. The roughness of the TiO₂ surface the possible network of SO₄²⁻/TiO₂ was increased with increasing the used amount of 1M-H₂SO₄ solution, which implies the SO₄²⁻ ions coordinated with TiO₂.⁶

Fig. 8 shows XRD patterns of SO₄²⁻/TiO₂ catalysts treated with different amount of 1M-H₂SO₄ solution. No significant change was observed at all catalysts, which indicates that the crystal structure did not change after impregnation of SO₄²⁻ ions onto TiO₂.
Fig. 7. SEM images of SO$_4^{2-}$/TiO$_2$ catalyst. (A) Pure TiO$_2$, (B) 5-SO$_4^{2-}$/TiO$_2$, and (C) 10-SO$_4^{2-}$/TiO$_2$ (Scale bar: 5µm)

Fig. 8. X-ray diffraction patterns of SO$_4^{2-}$/TiO$_2$ catalysts. (A) pure TiO$_2$, (B) 2-SO$_4^{2-}$/TiO$_2$, (C) 5-SO$_4^{2-}$/TiO$_2$, (D) 10-SO$_4^{2-}$/TiO$_2$, (E) 15-SO$_4^{2-}$/TiO$_2$, and (F) 20-SO$_4^{2-}$/TiO$_2$. 
3.2.2. Effect of Amount of Catalyst
Catalytic activity in synthesis of styrenated phenols from alkylation of phenol over the SO$_4^{2-}$/TiO$_2$ catalyst was investigated. Fig. 9 shows the effect of amount of catalyst on conversion of reactants and selectivity of products. Amount catalyst of 5wt% to reactants shows the highest DSP selectivity, 56.4%.

![Fig. 9. Effect of amount of catalyst on (A) conversions and (B) selectivities at 80°C over 5-SO$_4^{2-}$/TiO$_2$ catalyst. (Reaction time: 6hr)](image)

3.2.3. Effect of Amount of 1M-H$_2$SO$_4$ Solution
Fig. 10 shows effect of used amount of 1M-H$_2$SO$_4$ for SO$_4^{2-}$/TiO$_2$ preparation on conversions and selectivities. Conversions of phenol and styrene reached 100% over 5-SO$_4^{2-}$/TiO$_2$ and 2-SO$_4^{2-}$/TiO$_2$, respectively. Selectivity to DSP among SPs was the highest; the maximum selectivity to DSP has shown over 5-SO$_4^{2-}$/TiO$_2$ and 10-SO$_4^{2-}$/TiO$_2$ catalysts.

3.2.4. Effect of Reaction Temperature
Fig. 11 shows effect of reaction temperature on the catalytic activity over 10-SO$_4^{2-}$/TiO$_2$ catalyst, which was studied at different temperatures (40 ~ 140°C). This catalyst reaches 100% in both phenol and styrene conversions at over 80°C (Fig. 11A). Fig. 11 (B) shows the effect of reaction temperature on MSP, DSP, and TSP selectivity. Selectivity for DSP and TSP are increased with increased the reaction temperature, while MSP selectivity was decreased. The highest DSP selectivity was obtained at 100°C.
The alkylation of phenol with styrene to produce the styrenated phenol was investigated over the $SO_4^{2-}/ZrO_2$ and $SO_4^{2-}/TiO_2$ catalysts. Reaction temperature did not affect much on the conversions of phenol and styrene. Maximum selectivity to DSP over 15-$SO_4^{2-}/ZrO_2$ catalyst was 52.1% at reaction temperature of 100°C and reaction time of 6hr. Amount of catalyst to reactants was 15wt%. Selectivity to TSP was independent of all the conditions. It was known that selectivity to DSP was increased with increasing absorption peak of 1236cm$^{-1}$ corresponding to O-S-O bond. Conversions of phenol and styrene showed almost 100% over the 5-$SO_4^{2-}/TiO_2$ catalyst at reaction temperature of 100°C and reaction time of 6hr, and selectivity to MSP, DSP, and TSP were 31%, 66.8%, and 2.1%, respectively.

Acknowledgment:
This work was supported by the Human Resource Training Program for Regional Innovation and Creativity through the Ministry of Education and National Research Foundation of Korea.
(NRF-2014H1C1A1066844).

References
The Investigation of Applications of TiO2 Nanomaterials in Rutile and Anatase Structures onto Denim Fabric

Özlen Altun
Trakya University, Department of Chemistry, Turkey
ozlenaltun@yahoo.com

Nilgün Becenen
Trakya University, Vocational College of Technical Sciences, Turkey
nbecenen@yahoo.com

1. Background
For the first time in this study, TiO₂ nanomaterials in rutile and anatase structures were prepared and applied onto denim fabric by using an acrylic binder. The antibacterial and UV blocking properties of this fabric were evaluated.

2. Methods
Denim fabric was used in the experiments. This fabric was made using 100% cotton yarn by weaving. Warp and weft yarns were undyed, weaving type was 3/1 right hand twill and weight was 162 g/m². The TiO₂ nanomaterials in rutile and anatase structures were sprayed onto denim fabrics by using the spray gun method.

To investigate the in vitro antibacterial activity, denim fabric impregnation was performed with TiO₂ (rutile and anatase) nanomaterials separately. Antibacterial tests of quantitative percentage reduction test (Method AATCC-100) method was carried out against Staphylococcus aureus, Escherichia coli and Escherichia coli isolated from pasta.

The UV properties of the treated fabric were investigated by using UV/Vis transmittance analyzer. The blank reference was air. The UV properties of the untreated samples were compared with the spectra collected from the same fabric treated with TiO₂ nanomaterials with rutile and anatase structures and the effectiveness in shielding UV radiation was evaluated by measuring the UV absorption, transmission and reflection.

3. Expected Results
The surfaces of treated fabrics were observed with SEM microscopy. Figure 1 shows an SEM image of the untreated fabric and in Figure 2 a-b SEM micrographs illustrate the nano-scaled TiO₂ (rutile) and TiO₂ (anatase) nanomaterials on the same fabric samples, respectively.
In Figure 2 a-b the nanoparticles are well dispersed on the fabric surfaces, although some agglomerated nanomaterials are still visible. The particle size plays a primary role in determining their adhesion to the fabric. It is reasonable to expect that the largest particle agglomerates will be easily removed from the fabric surface, while the smaller particles will penetrate deeper and adhere strongly to the fabric matrix.

The quantitative bacterial reduction for different nanomaterial-treated dyed denim fabric was studied by percentage reduction test (AATCC-100) and the results are shown in Table 1. According to Table 1, TiO$_2$ (rutile) and TiO$_2$ (anatase) nanoparticles have significant antibacterial activity against *Staphylococcus aureus* and they are inactive against *Escherichia coli* and *Escherichia coli* isolated from pasta.

<table>
<thead>
<tr>
<th>Fabric sample</th>
<th><em>Staphylococcus aureus</em></th>
<th><em>E. Coli</em></th>
<th><em>E. Coli</em> isolated from pasta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>No reduction</td>
<td>No reduction</td>
<td>No reduction</td>
</tr>
<tr>
<td>Nano TiO$_2$ (rutile)</td>
<td>25.96 (%)</td>
<td>No reduction</td>
<td>No reduction</td>
</tr>
<tr>
<td>Nano TiO$_2$ (anatase)</td>
<td>34.73 (%)</td>
<td>No reduction</td>
<td>No reduction</td>
</tr>
</tbody>
</table>

Solar UV radiation is composed of UV-A (400-315 nm), UV-B (315-290 nm) and UV-V (290-200 nm) (Table 2). UV spectra were recorded for untreated and treated denim fabrics by
measuring the absorbance, transmission and reflection. Untreated fabric did not absorb UV radiation while the treatment with nanosized TiO₂ (rutile and anatase particles on the dyed denim fabrics increased the absorption of UV light over the entire investigated UV spectrum.

<table>
<thead>
<tr>
<th>Fabric sample</th>
<th>UPF values</th>
<th>Protection</th>
<th>UV-A values</th>
<th>UV-B values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>7.11</td>
<td>Insufficient protection</td>
<td>18.30</td>
<td>13.36</td>
</tr>
<tr>
<td>Nano TiO₂ (rutile)</td>
<td>17.96</td>
<td>Good protection</td>
<td>9.86</td>
<td>5.39</td>
</tr>
<tr>
<td>Nano TiO₂ (anatase)</td>
<td>31.17</td>
<td>Good protection</td>
<td>6.79</td>
<td>3.45</td>
</tr>
</tbody>
</table>

Keywords: TiO₂ (rutile), TiO₂ (anatase), Antibacterial Activity, Denim Fabric, UV Tests
ICCBES-1174
Manganase Cyclohexane Dicarboxylic Acid: Synthesis and Examination of its Properties

Gühergül Ulucam
Trakya University, Faculty of Science, Department of Anorganik Chemistry, Turkey
E-mail: gulergul@trakya.edu.tr

Özlen Altun
Trakya University, Faculty of Science, Department of Anorganik Chemistry, Turkey
E-mail: ozlenaltun@yahoo.com

1. Background
In this work, Manganese salt of cyclohexane dicarboxylic acid was synthesized and its properties were examined. The preparation and structural elucidation of the complexes was undertaken by using physico-chemical and spectroscopic methods (UV/Vis, FT-IR, XRD and TG-DTA). In addition, antibacterial of the complexes were studied screened against bacteria.

2. Methods
10g NaOH in 40mL water was added to solution of 20g cyclohexane dicarboxylic acid in 150mL ether. After NaOH addition was completed, 5g MnSO₄.H₂O solution in 7mL water was added at 85-90°C. Mixture was stirred about one hour. During the progress of the reaction ether was lost gradually from the system. Finally the liquid phase was filtered giving brown residue which was washed with distilled water to get rid of the water soluble impurities. Brown solid was oven dried giving a compound with a spectra consistent with the spectra of the compound obtained in Method I.

3. Expected Results
In this research, the synthesis and the properties of a coordination compound of cyclohexane dicarboxylic acid and Mn (II) were studied. Spectroscopic methods showed the possible structure of manganese cyclohexane dicarboxylic acid. Manganese cyclohexane dicarboxylic acid is a brown solid

Color: Brown. Yield: 89%. M.p.: 282 °C. Elemental Anal. (%), calcd. C, 42.6; H, 4.26 Found: C, 42.53; H, 4.4. UV/Vis bands (nm): 282, 489. IR bands (cm⁻¹) of manganese dicarboxylic acid: 2944cm⁻¹ (vCH), 1605-1558cm⁻¹ (vcarboxyl anions), 1400cm⁻¹ (vCO). XRD (2θ): 5.2300, 14.9200 and 19.5600.
When the elemental analyses of the complex was investigated, the calculated and found ratios were found to be 1:1 in the complex of cyclohexane dicarboxylic acid in the presence of manganese (II). The elemental analyses indicate that the obtained manganese cyclohexane dicarboxylic acid has 1:1 stoichiometry. According to specific and equivalent conductivity values obtained for this complex, while specific values of cyclohexane dicarboxylic acid in the presence of manganese (II) increase with concentration, the equivalent conductivity values decrease. These results show the presence of ions belonging to the system.

The UV/Vis spectra of free cyclohexane dicarboxylic acid molecule displays an absorption band at 302 nm, whereas the complex display a number of distinct bands at 290 and 511 nm for cyclohexane dicarboxylic acid + manganese (II). The absorption band at 290 nm are attributed to π-π* transitions. The high energy band at 511 nm originated from the d-d transitions.

The IR spectra of the free ligand (cyclohexane dicarboxylic acid) and its Mn (II) complex is interpreted by comparing the spectra of the complex with that of the free ligand. The comparison of the band positions of various vibrations are ascertained with good evidence. In the infrared spectrum of complex, two bands centered at 1593 and 1532 cm\(^{-1}\) are attributed to the \(\nu_{\text{carboxyl anions}}\) vibrations. The band at about 2944 cm\(^{-1}\) is assigned to the absorption of the \(\nu_{\text{CH}}\) vibrations and the \(\nu_{\text{CO}}\) stretchings of the complex are found in the frequency range about 1593 and 1532 cm\(^{-1}\).

The XRD (Powder Pattern) (Figure 1) spectra of the complex is indexed by an X-Ray diffractometer. Three peaks are determined for the complex at 5.2300, 14.9200 and 19.5600 (2θ) and the interplanar spacing (d) has been calculated as 16.97784, 5.93296 and 4.53476, respectively. All the important peaks have been indexed and the observed values of the interplanar distance are compared with the calculated ones.

Thermogravimetric analysis of manganese cyclohexane dicarboxylic acid indicated, two steps for decomposition and the amount of water in the composition of the molecule. The decomposition of two carboxyl groups can be monitored from the thermogram. Up to 181 °C, a water molecule leaves the compound, then between 306-724°C, organic component is decomposed. The remaining compound over 724°C was determined as MnO. After these observations we concluded that the structure of manganese cyclohexane dicarboxylic acid is \([\text{Mn(C}_8\text{H}_{10}\text{O}_4])\cdot\text{H}_2\text{O}\). The structural formula of the compound is shown in below.
3.1 Biological Activity Results

The synthesized complex is estimated for their microbial toxicity against a set of bacterial strains. The antibacterial activity of the complex is tested using the agar well-diffusion method. The results show that the complex has significant antibacterial activity.

Keywords: Mn (II), Cyclohexane dicarboxylic acid, Synthesis, Spectroscopy, Antibacterial Activity
1. Background

For the first time in this study, ZnO and Ag nanomaterials were prepared and applied onto denim fabric by using an acrylic binder. The antibacterial and UV blocking properties of this fabric were evaluated.

2. Methods

Nanomaterials were applied to the face side of the denim fabric (100% cotton yarn by weaving. Warp and weft yarns were undyed, weaving type was 3/1 right hand twill and weight was 162 g/m²) with concentration of 1%, material to liquor ratio 1:20, and acrylic binder 1%. The fabric was cut to the size of 30 x 30 cm and was coated with nanomaterials by using a spray gun.

To investigate the antibacterial activity of denim fabric impregnation was done with ZnO and Ag nano particle separately. Antibacterial test Method AATCC-100and Method AATCC-147 were carried out against Staphylococcus aureus, Escherichia coli and Escherichia coli isolated from pasta.

The UV properties of the treated fabric were investigated by using UV/Vis transmittance analyzer. The blank reference was air. The UV properties of the untreated samples were compared with the spectra collected from the same fabric treated with ZnO and Ag nanomaterials and the effectiveness in shielding UV radiation was evaluated by measuring the UV absorption, transmission and reflection.

3. Expected Results

The surfaces of treated fabrics were observed with SEM microscopy. Figure 1 shows an SEM image of the untreated fabric and in Figure 2 a-b SEM micrographs illustrate the nano-scaled ZnO and Ag nanomaterials on the same fabric samples, respectively.
In Figure 2 a-b, the nanoparticles are well dispersed on the fabric surfaces, although some aggregated nanomaterials are still visible. The particle size plays a primary role in determining their adhesion to the fabric. It is reasonable to expect that the largest particle agglomerates will be easily removed from the fabric surface, while the smaller particles will penetrate deeper and adhere strongly to the fabric matrix.

The quantitative bacterial reduction for different nanomaterial-treated dyed denim fabric was studied by percentage reduction test (AATCC-100) According to Table 1. ZnO nanoparticles show significant antibacterial activity against *Staphylococcus aureus*, they have moderate activity against *Escherichia coli* and are inactive against *Escherichia coli* isolated from pasta. Nano Ag particles have significant antibacterial activity against *Staphylococcus aureus*, *Escherichia coli* and *Escherichia coli* isolated from pasta.

<table>
<thead>
<tr>
<th>Fabric sample</th>
<th><em>Staphylococcus Aureus</em></th>
<th><em>E. Coli</em></th>
<th><em>E. Coli</em> isolated from pasta</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>No reduction</td>
<td>No reduction</td>
<td>No reduction</td>
</tr>
<tr>
<td>Nano ZnO</td>
<td>60.33 (%)</td>
<td>20.32 (%)</td>
<td>No reduction</td>
</tr>
<tr>
<td>Nano Ag</td>
<td>62.50 (%)</td>
<td>51.61 (%)</td>
<td>48.21 (%)</td>
</tr>
</tbody>
</table>
Solar UV radiation is composed of UV-A (400-315 nm), UV-B (315-290 nm) and UV-V (290-200 nm) (Table 2). UV spectra were recorded for untreated and treated denim fabrics by measuring the absorbance, transmission and reflection. Untreated fabric did not absorb UV radiation while the treatment with nanosized ZnO, and Ag particles on the dyed denim fabrics increased the absorption of UV light over the entire investigated UV spectrum.

<table>
<thead>
<tr>
<th>Fabric sample</th>
<th>UPF values</th>
<th>Protection</th>
<th>UV-A values</th>
<th>UV-B values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>7.11</td>
<td>Insufficient protection</td>
<td>18.30</td>
<td>13.36</td>
</tr>
<tr>
<td>Nano ZnO</td>
<td>45.52</td>
<td>High protection</td>
<td>1.05</td>
<td>1.03</td>
</tr>
<tr>
<td>Nano Ag</td>
<td>16.03</td>
<td>Good protection</td>
<td>8.67</td>
<td>6.40</td>
</tr>
</tbody>
</table>

Keywords: Inorganic Nanomaterials, Denim Fabric, Coating, Antibacterial Activity, UV protection
ICCBES-1185
Preparation of MoS$_2$ Based MRI Contrast Agent for in Vivo Bio-Imaging

Hsieh-Chih Tsai
Graduate Institute of Applied Science and Technology,
National Taiwan University of Science and Technology, Taiwan
h.c.tsai@mail.ntust.edu.tw

1. Background
In this work, we report a core-shell magnetic MoS$_2$ and gadolinium chelate for use as an improved MRI contrast agent. Unlike, molecule-based gadolinium complex contrast agents such as DTPA-Gd and Cys-DTPA-Gd typically are unstable and would release toxic gadolinium ions when exposed to biofluids. This core-shell structure with tight packing characteristic would also decrease the exposure of free gadolinium ions and lower toxicity while improving imaging performance. In vivo MRI imaging also revealed hyperintense signal in the heart, kidney, and bladder while quantitative signal analysis confirmed the enhancement of blood circulating property of the core-shell material as well as adequate clearance from the body. These results distinctly revealed that this new core-shell magnetic nanomaterial could be used as a MRI contrast agent, especially for heart, kidney, and bladder-related diagnosis.

2. Methods

Synthesis of M-Cys-DTPA-Gd Nanoparticle
First, the surface functional group was chemically modified by cysteamine. MoS$_2$-Cys-DTPA was synthesized by conjugating the amine group of MoS$_2$-Cys to the carboxylic group of DTPA dianhydride. Gadolinium ion was chelated in MoS$_2$-DTPA to form a stable MoS$_2$-MoS$_2$-DTPA-Gd nano cluster.

Gadolinium Leaching Analysis
The stability of the encapsulation of Gd$^{3+}$ within M-Cys-DTPA-Gd was determined by performing a complexometric titration of free Gd$^{3+}$ leaching from M-Cys-DTPA-Gd, using xylenol orange as indicator. Xylenol orange exhibits a yellow color in a noncomplex form ($\lambda_{\text{max}} = 432$ nm in UV–vis absorption spectrum), while a red color is observed from the complex of xylenol orange with Gd$^{3+}$. By measuring the absorption at the wavelength of 573 nm, a quantitative analysis of free Gd$^{3+}$ is feasible.

Cytotoxicity Test (MTT Assay)
In vitro cytotoxicity of all synthesized nanomaterials was evaluated using the standard (3-(4, 5-dimethylthiazol-2-yl)-2, 5-diphenyltetrazolium bromide) (MTT) assay. Briefly, HUVEC cells were seeded in a 96-well plate at a density of 2 x 10$^4$ per well and incubated with medium
overnight (37\(^\circ\) C, 95% air, and 5% CO\(_2\)). The medium was replaced with 100µl of fresh medium containing synthesized contrast agents and incubated for another 24 h. The MTT reagent was removed and formazan crystals were solubilized with DMSO. An ELISA microplate reader was used to determine HUVEC viability.

In vivo positive contrast imaging:
In vivo positive MRI imaging was performed on a 7T MRI System (Bruker Biospec 70/30). Three mice were used in each group for in vivo MRI measurement. Female ICR mice were purchased from BioLASCO (Taiwan Co., LTD), maintained, and anaesthetized by isoflurane inhalation in accordance with the Animal Care and Use Committee at National Taiwan University (NTU). Positive MRI imaging was performed according to the following parameters: repetition time (TR) = 11.3 ms, echo time (TE) = 2.1 ms, FOV = 90 x 40 mm, flip angle = 15, slice thickness = 0.7 mm, number of requisition = 6, resolution = 256 x 128 pixels. The magnetic nanomaterial was injected via tail vein at the dose of 0.2 mm/kg body weight in buffer saline.

3. Expected Results and Conclusion
Structural detail of the nanomaterials was investigated using transmission electron microscopy (TEM). M-Cys aggregates which became disaggregated after DTPA conjugation. Particle sizes could be controlled by adjusting the M-Cys-DTPA ratio. The ratios such as 1:2 and 1:3 would produce bulky structures, which is unsuitable for vascular applications Complex formation between M-Cys-DTPA and gadolinium led to an increase in particle size as well as the formation of a visible core-shell structure. The size of M-Cys-DTPA-Gd nanoparticle was approximately 180 nm, which was observed from TEM and DLS results. The leaching of free gadolinium ions in M-Cys-DTPA-Gd was confirmed by xylenol orange as indicator. It has been noted that coordination of Gd3+ with xylenol orange could result in the change of color (from yellow to pink) due to the deprotonation from complex formation. The results indicate that only negligible amount of gadolinium ions (0.4% of gadolinium from M-Cys-DTPA-Gd) was leached from the M-Cys-DTPA-Gd particles. Low cytotoxicity is an important attribute of engineered biomedical nanomaterials. The materials were incubated with human umbilical vein endothelial cells (HUVEC) and viability was assessed by MTT assay. Concentration-dependent relative cell viability was observed after exposure to M-Cys-DTPA-Gd, Cys-DTPA-Gd and DTPA-Gd, respectively. M-Cys-DTPA-Gd was less toxic than DTPA-Gd perhaps due to minimum release of gadolinium ions from its core-shell structure, while the polymeric Cys-DTPA-Gd was least toxic. Molecule-based gadolinium complex contrast agents such as DTPA-Gd and Cys-DTPA-Gd typically are unstable and would release toxic gadolinium ions when exposed to biofluids. In contrast, nanomaterial-based gadolinium chelates with gadolinium ions binding tightly to MoS2 are less likely to release the toxic ions. The performance of synthesized contrast agents on contrast magnification was evaluated in mice.
Hyperintense signals appeared in the kidney, heart, and bladder after the administration of M-Cys-DTPA-Gd due to the enhanced paramagnetic property. On the other hand, glomerular filtration and lack of contrast enhancement would appear after respective administration of DTPA-Gd and Cys-Gd. Distinctive signal enhancing property demonstrates the high performance of M-Cys-DTPA-Gd core-shell nanomaterial as positive MRI contrast agents.

In conclusion, gadolinium chelate functionalization onto MoS2 nanomaterials resulted in phase conversion from 2H to 1T state. Consequently, the gadolinium shell greatly enhanced magnetic property and T1 relaxation while lowering toxicity. In vivo MRI imaging revealed hyperintense signal in the heart, kidney, and bladder while quantitative signal analysis confirmed the enhancement of blood circulating property of the core-shell material as well as adequate clearance from the body. These results distinctly revealed that this new core-shell magnetic nanomaterial could be used as a MRI contrast agent, especially for heart, kidney, and bladder-related diagnosis.

Keywords: MoS2 based contrast agent, Gd leaching, cell toxicity, nanoparticle
ICCBES-1203
Folate-Targeted and Thermo-Responsive Mixed Micelles for Photothermal and Photodynamic Therapy

Yu-Ying Chien, Ching-Yi Chen, Tung-Yun Wang
Department of Chemical Engineering, National Chung Cheng University, Taiwan
E-mail: chmcyc@ccu.edu.tw

Abstract

1. Objectives and Goals
Indocyanine green (ICG) is a near-infrared (NIR) fluorescent dye approved by the U.S. Food and Drug Administration (FDA) for clinical use. It has several applications, such as in vivo imaging, converting NIR light into heat for photothermal therapy or generating reactive oxygen species for photodynamic therapy. However, ICG has been proved to have poor aqueous stability, concentration-dependent aggregation, lack of target specificity and quick clearance from body that limit its applications. In this study, a series of folate-targeted and thermo-responsive mixed micelles was developed for encapsulation of ICG to overcome these limitations.

2. Methods
Two series of amphiphilic block copolymers were synthesized via atom transfer radical polymerization: Poly(ε-caprolactone)-b-poly-[triethylene glycol methacrylate-co-N-(2-(methacrylamido)ethyl folic amide)] (PCL-b-P(TEGMA-co-FA), PTF) and Poly(ε-caprolactone)-b-poly(diethylene glycol monomethyl ether methacrylate (PCL-b-PDEGMA, PD). Different PTF/PD weight ratios were utilized to prepare mixed micelles for encapsulation of ICG. The ICG-loaded mixed micelles were characterized via dynamic light scattering (DLS), transmission electron microscopy (TEM), UV-visible spectroscopy (UV-vis), and fluorescence spectrophotometer. The thermo-responsive behaviors of mixed micellar solutions were determined by their optical transmittance as a function of temperature. The stability of ICG-loaded mixed micelles and temperature response under laser irradiation were also investigated. The cell specific targeting and the photothermal and photodynamic cytotoxicity of ICG-loaded mixed micelles were evaluated using HeLa cell line (folate receptor overexpression) and HT-29 (lack of folate receptor expression).

3. Conclusion
The ICG-loaded mixed micelles showed good storage and aqueous stability, and a preferable thermo-responsive behavior. The highest loaded capacity of ICG can reach 2.52%. In addition, the ICG-loaded mixed micelles exhibited good temperature response and singlet oxygen
generation efficiency under irradiation with 808 nm laser light. The target specificity was evaluated using HeLa cells and HT-29 cells. The in vitro studies showed the higher cytotoxicity toward HeLa cells under NIR light irradiation was attributed to the selective internalization of ICG-loaded mixed micelles through receptor-mediated endocytosis. These results indicate the mixed micelles improve the aqueous stability of ICG and have potential as targeted drug delivery system.

Keyword: amphiphilic block copolymers · photothermal therapy · photodynamic therapy
ICCBES-1204
Colloidal Stability of Poly (Sulfobetaine Methacrylate)-Grafted Gold Nanoparticles in Protein Solutions

Chia-Chang Fan, Ching-Yi Chen
Department of Chemical Engineering, National Chung Cheng University, Taiwan
E-mail address: chmcyc@ccu.edu.tw

Abstract
1. Objectives and Goals
Zwitterionic polymers with anionic and cationic groups simultaneously in the repeat unit, have excellent hydrophilic properties, excellent thermal and chemical stability, good bio-compatibility, non-fouling properties and special "antipolyelectrolyte effect". Gold nanoparticles (AuNPs) have several advantages, including easy fabrication and surface modification, good bio-compatibility, and special optical properties. In this study, we aim to develop the highly stable and bio-compatible AuNPs as drug-delivery carriers by grafting zwitterionic polymers on the surface of AuNPs. We expect the super hydrophilic and non-fouling properties of zwitterionic polymers can improve the stability and bio-compatibility of zwitterionic polymers-grafted AuNPs in BSA protein solution.

2. Methods
In this study, a thiol initiator bis [2- (2'-bromoisobutyryloxy) ethyl] disulfide was used to synthesize poly(sulfobetaine methacrylate) (PSBMA) via atom transfer radical polymerization (ATRP). Different molar ratios of initiator and SBMA as 1:30, 1:90, and 1:200 were prepared to investigate the effect of PSBMA molecular weight on phase transition temperature and properties of PSBMA-grafted AuNPs. The molecular weights and molecular weight distributions of PSBMA were determined via gel permeation chromatography (GPC) and nuclear magnetic resonance (1H-NMR). The prepared PSBMA-grafted AuNPs were characterized via dynamic light scattering (DLS), UV-visible spectroscopy (UV-vis), transmission electron microscopy (TEM), and thermo gravimetric analysis (TGA). Moreover, the phase transition behaviors (upper critical solution temperature (UCST)) of PSBMA in aqueous solutions were determined by measuring the optical transmittance of the PSBMA solution as a function of temperature. The stability of PSBMA-grafted AuNPs in PBS and protein solutions was also investigated systematically.

3. Conclusion
A series of PSBMA-grafted AuNPs was successfully synthesized. DLS results indicated that hydraulic diameters of PSBMA-grafted AuNPs increased with increasing molecular weight of PSBMA from the 34 nm (bare AuNPs) to 46 nm, 53 nm and 121 nm. TEM images showed the
size of AuNPs around 15 nm with good dispersibility. Phase transition behaviors indicated the PSBMA-grafted AuNPs exhibited an UCST, which increased with increase in the molecular weight of PSBMA. This might be attributed to the enhancement of the mutual intra- and interchain associations of the sulfobetaine groups in aqueous solutions, resulting in an increase in their UCSTs. In addition, the colloidal sizes of PSBMA-grafted AuNPs were monitored by DLS for two months in BSA protein solution at 37°C. The results showed the PSBMA-grafted AuNPs having excellent dispersion and stability. Therefore, the PSBMA-grafted AuNPs have the potential to be applied as drug-delivery carriers.

Keywords: Zwitterion、Gold nanoparticle、Nonbiofouling、Drug-delivery carriers
Comparison of Effect of Non-Meat Natural Ingredients on Physico-Chemical Properties of Pork Emulsion

Sangkeun Jin, Sungho Kim, Sora Ha, Heejun Jung
Department of Animal Resources Technology, Gyeongnam National University of Science and Technology, Republic of Korea
E-mail address: skjin@gntech.ac.kr

Chulwook Kim, Jaeyoung Kim, Taewan Kim, Samwoong Kim, Jeongim Ha, Eunmi Lee, Jungseok Choi
Swine Science and Technology Center, Gyeongnam National University of Science and Technology, Republic of Korea

1. Background/ Objectives and Goals
Recently, worldwide consumption of meat products has increased rapidly. Until now, chemical additives have been widely used in commercial applications, due to low price and high efficiency. However, now is that consumers tend to prefer meat products without chemical additives.

Therefore, this study was conducted to compare the effect of non-meat natural substances as a binder on the physico-chemical properties of pork emulsion.

2. Methods
Fresh lean pork and backfat from LYD (Landrace x Yorkshire x Duroc) was purchased to manufacture pork emulsion. Commercial non-meat natural materials (Isolated soy protein, sodium caseinate, granulated egg white, whey protein concentrate, cattle collagen fiber, pig blood plasma, pig blood hemoglobin, sodium alginate, seaweed powder) were purchased from Dongbang foodmaster co., Ltd., and used in the experiment. Analysis items were pH, shear force, color and sensory evaluation.

3. Expected Results/ Conclusion/ Contribution
The pH values of pork emulsions were decreased by the addition of non-meat materials compared to control. The shear force values were higher in the pork emulsion with granulated egg white, whey protein concentrate, cattle collagen fiber, and pig blood plasma than those of the other ingredients (p<0.05). The redness value of pork emulsion with pig blood hemoglobin was the highest among the non-meat natural materials. In the result of sensory evaluation, no significant difference were observed in the treatment groups.
Keywords: Non-meat natural ingredients, pork emulsion, pH, shear force, color
The Effects of VO₄ Substitution on the Sintering and Microwave Properties of Ca₄(La₄Pr₂)(SiO₄)₄(PO₄)₂O₂ and Ba₄(La₄Pr₂)(SiO₄)₆O₂

Hong Bo Yang, * Y-J Lin
Department of Materials Engineering, Tatung University, Taiwan
Email: yhb435@gmail.com

S-F Wang
Institute of Materials Science and Engineering,
National Taipei University of Technology, Taiwan

Recent studies have pointed out that oxyapatites are suitable for microwave applications. Oxyapatite has formula as M₁₀(RO₄)₆O₂ and could have broad range of compositions and cation substitution. Its composition has a great influence on the microwave properties. In this research, we used solid-state reaction method to fabricate samples of two types of oxyapatite with various VO₄ substitutions: Ca₄(La₄Pr₂)(SiO₄)₄(PO₄)₂₋ₓ(VO₄)ₓO₂ (x = 0, 1, 2) and Ba₄(La₄Pr₂)(SiO₄)₆₋ₓ(VO₄)ₓO₂ (x = 0, 2, 4, 6). The effects of VO₄ substitutions on the sintering and microwave properties were investigated.

The results showed that VO₄ substitutions could reduce the densification temperature from 1500°C to 1400°C in both types of oxyapatites. However, it also decreased quality factor (Qxf) as well as the stability of resonant frequency against temperature (tₕ) variation. The VO₄ substitution had stronger deteriorating effects in microwave properties in Ba₄(La₄Pr₂)(SiO₄)₆O₂ than in Ca₄(La₄Pr₂)(SiO₄)₄(PO₄)₂O₂. Comparing Ca₄(La₄Pr₂)(SiO₄)₄(PO₄)₂O₂ and Ca₄(La₄Pr₂)(SiO₄)₄(PO₄)₂(VO₄)O₂, the Qxf decreased from 15130 GHz to 14840 GHz and the tₕ increased from 10.1 ppm/°C to 11.6 ppm/°C. Contrastingly, comparing Ba₄(La₄Pr₂)(SiO₄)₆O₂ and Ba₄(La₄Pr₂)(SiO₄)₆(VO₄)O₂, the Qxf decreased from 27150 GHz to 11450 GHz and the tₕ increased from -2.8 ppm/°C to 24.0 ppm/°C.

Keywords: oxyapatite, microwave properties, sintering, quality factor, dielectric constant
Effective Suppression of PdSn\(_4\) Growth in the Solder Joints with Pd substrate by Minor Ga Additions

Chao-hong Wang\(^*\) and Kuan-ting Li

Department of Chemical Engineering, National Chung Cheng University, Taiwan

Email: chmchw@ccu.edu.tw

This research investigates the effects of Ga addition on the interfacial reactions between Pd and Sn-Ga (0.1wt.\%-1wt.\%Ga) solders. The reactions were carried out in solid-state aging at 160~200\(^\circ\)C and liquid-state aging at 250\(^\circ\)C. For the Sn/Pd interfacial system, PdSn\(_4\) is the major reaction phase with an extremely high growth rate. The PdSn\(_4\) growth was controlled by volume diffusion and Sn is the dominant diffusion species. However, excessive growth of the interfacial intermetallic compound (IMC) deteriorates the mechanical properties of solder joints. If the IMC growth could be slowed, it would benefit the reliability of solder joints. In this study, it was found that minor Ga addition can effectively inhibit the PdSn\(_4\) growth. In the solid-state reaction, only 0.1wt\%Ga addition can suppress the PdSn\(_4\) growth by ~50\%, in comparison with the Sn/Pd interface. When the Ga content increased to 0.5wt.\%, it was further reduced by over 90\%. A thin PdGa phase layer (~1 \(\mu\)m thick) was formed at the PdSn\(_4\)/Pd interface, which can be regarded as the diffusion barrier layer. Both two reaction phases, i.e., PdSn\(_4\) and PdGa, were further identified by transmission electron microscopy (TEM). The growth kinetics was also systematically investigated. In the liquid-state reaction, a similar reduction in the PdSn\(_4\) growth was found. In contrast, the inhibition effect was not as strong as in the solids-state reaction and the PdGa phase was not formed. The growth inhibition is likely that the Ga doping in the PdSn\(_4\) lattice retards the Sn diffusion.

Keywords: Lead-free solders, IMC growth, suppression, minor addition.
ICCBES-1271

Thermal Instability Study of Electrolytes Reacted with Various Lithiated Cathode Materials of lithium-Ion Battery by DSC

Chih-Yi, Lee, Kai-Syuan, Lin, and Chen-Shan Kao*
Department of Safety Health and Environmental Engineering,
National United University, Taiwan, ROC
E-mail address: jcsk@nuu.edu.tw

Yih-Shing Duh
Department of Safety Health and Environmental Engineering,
National United University, Taiwan, ROC
Department of Occupational Safety and Health,
Jen-Teh Junior College of Medicine, Nursing and Management, Taiwan, ROC
E-mail address: yihshingduh@yahoo.com.tw

Abstract
Lithium-ion battery becomes the most important energy supplier with the rapid development of the portable electric and electronic products. However overheating, fire and explosion accidents occurred from time to time owing to battery thermal runaway. One of the possible reasons is the exothermic reaction between the lithiated cathode materials and electrolytes.

In this study thermal curves of eight lithiated cathode materials reacted with different electrolytes that are commonly used in lithium-ion battery are performed in a Mettler TA-4000 System coupled with a differential scanning calorimetry (DSC822) measuring cell. Disposable crucible (ME-26732) which can withstand up to 100 bars is used for detecting thermal curves. Data are acquired and stored for further evaluation. Scanning rate is selected to be 4K min$^{-1}$ in programmatic ramp up to 500$^\circ$C for the reason of sustaining better thermal equilibrium inside the crucible.

Electrolytes, namely, dimethyl carbonate (DMC) and mixture of DMC/EC (ethylene carbonate) with the ratio of 1 : 1 reacted with eight cathode materials, i.e., lithium iron phosphate (LiFePO$_4$), lithium manganese oxide (LiMn$_2$O$_4$), lithium nickel manganese cobalt oxide (LiNi$_{1/3}$Mn$_{1/3}$Co$_{1/3}$O$_2$, NMC333), LiNi$_{0.5}$Mn$_{0.3}$Co$_{0.2}$O$_2$ (NMC532), (LiNi$_{0.8}$Co$_{0.15}$Al$_{0.05}$O$_2$, NCA), etc. are measured and accessed, respectively. Results indicate that the lowest onset temperature occurred at the reaction of lithium manganese oxide (LiMn$_2$O$_4$) with DMC as well as DMC/EC mixture. Furthermore, lithium iron phosphate (LiFePO$_4$) reacted with electrolytes do not exhibit exothermic behaviors and turns out to have the best thermal stability than other lithiated cathode materials.
These phenomena provide much more clear sights for searching the root causes to explain or link the incidents of overheating, fire or explosion encountered in lithium-ion batteries.

Keywords: lithiated cathode material, onset temperature, thermal instability, electrolyte
ICCBES-1288

Surface Modification of NF270 for Enhancing Antifouling Ability and PPCP Rejection

Yi-Li Lin*, Jia-Zheng Tsai, Nai-Yun Zheng, Pei-Tsi Chang, Yu-Chi Chang

Department of Safety, Health and Environmental Engineering, National Kaohsiung First University of Science and Technology, Taiwan
E-mail address: yililin@nkfust.edu.tw

Abstract

The commercially available nanofiltration membrane, NF270, was modified using the in-situ concentration-polarization-enhanced radical graft polarization method to improve the removal of pharmaceutical and personal care products (PPCPs) and anti-fouling capability. 3-sulfopropyl methacrylate potassium salt (SPM) and 2-hydroxyethyl methacrylate (HEMA) were used for membrane modification. Humic acid (HA) was chosen as the target organic foulant in this study. Six PPCPs including ibuprofen (IBU), carbamazepine, sulfadiazine, sulfamethoxazole, sulfamethazine, and triclosan (TRI) were selected as the model compounds. The surface characteristics of modified NF270 including surface morphology, hydrophobicity and salt rejection were evaluated. The amount of PPCP adsorption on the modified NF270 was also extracted for quantification. The modified NF270 can reduce 32-50% flux decline during HA fouling, which is significant compared to 53% flux decline of the virgin membrane. The salt rejection of NaCl increased 53% compared to the virgin membrane. PPCP rejections of the clean modified NF270 and HA-fouled NF270 increased 0-55% and 0-52%, respectively, compared to the virgin membrane. Both SPM and HEMA can increase the hydrophilicity of NF270 by decreasing the contact angles. Although PPCP adsorption on the modified NF270 increased significantly for the two highly hydrophobic compounds (IBU and TRI), no penetration across membrane happened because rejections of IBU and TRI remained the same level before and after modification. Less foulant deposit on the modified membrane was observed using SEM pictures. Therefore, the modification of NF270 using the in-situ concentration-polarization-enhanced radical graft polarization method was proven to be effective for fouling control and high PPCP rejections.

Keyword(s): In-situ modification, Concentration-polarization, Antifouling, Nanofiltration, Pharmaceutical and personal care products (PPCPs)
ICCBES-1103
Potential Application of Carbon Materials in Reducing Toxicity of Human Islet Amyloid Polypeptide

Li Wang, Shoujun Zhu, Tong Lu, Fei Li*
State Key Laboratory of Supramolecular Structure and Materials, Jilin University, PR China
E-mail address: feili@jlu.edu.cn

Guangji Zhang
College of Life Science, Jilin University, PR China

The inhibition of amyloid fibril formation has been believed to be a potential strategy in development of therapy for neurodegenerative diseases. Carbon dots (CDs), a newly-emerging class of nano-sized fluorescent carbon materials, have drawn increasing attention because of their potential applications in drug delivery and bio-imaging. In this study, we intended to explore the potential use of these materials in the pharmaceutical of amyloidosis.

Two kinds of CDs including graphene quantum dots and polymer carbon dots were prepared and characterized. The human islet amyloid polypeptide (hIAPP), a peptide hormone associated with type 2 diabetes mellitus disease, was used in this study. The modulations of CDs on the fibrillation of hIAPP were examined by ThT binding assay, TEM and AFM imaging measurements. The inhibition effects of the CDs on the cellular toxicity of hIAPP were estimated by the MTT assay in INS-1 cells.

The results showed that the graphene quantum dots promote the fibrillation of hIAPP, while polymer carbon dots inhibit the formation of hIAPP fibrils. The perturbation mechanism was associated with the property of conjugated chemical groups on the surface of the CDs and the core structure of the CDs. Despite exerting an opposite effect on hIAPP fibrillation, polymer carbon dots and graphene quantum dots were highly potent in reducing the cytotoxicity of hIAPP. Our findings showed a potential application of CDs in the therapy of amyloidogenic diseases.

Keywords: Carbon dots; hIAPP fibrillation; Cytotoxicity
ICEAI-1012
Interfacial Reactions of Lead-Free Solders with the Ni-xPd Alloys

Pei Yu Chen
Department of Material Science and Engineering
National Taiwan University of Science and Technology, Taiwan
b10230004@mail.ntust.edu.tw

Yi Shan Li
Department of Material Science and Engineering
National Taiwan University of Science and Technology, Taiwan (R.O.C.)
m10104314@mail.ntust.edu.tw

Yee Wen Yen*
Department of Material Science and Engineering
National Taiwan University of Science and Technology, Taiwan (R.O.C.)
ywyen@mail.ntust.edu.tw

1. Background
Nickel (Ni) is considered a good barrier layer because of its lower reactivity with solders. Although Ni can efficiently reduce the intermetallic compound (IMC) growth rate, it is well known that the Ni layer is consumed faster during the interfacial reaction with Pb-free solders than with lead-based solders. A minor Palladium (Pd) addition into the Ni substrate was applied to improve the Ni barrier layer reliability. Thus, the Ni-Pd alloys have high potential to be a diffusion barrier to replace the Ni layer. Because of environmental consciousness and legislation, such as the waste electrical and electronic equipment directive (WEEE) and restriction of hazardous substances directive (RoHS), Pb-free solders have nearly completely replaced lead-tin (Pb-Sn) solders in the electronic industry. The Sn is a basic element in Pb-free solders and Sn-3.0 wt%Ag-0.5wt%Cu (SAC) and Sn-9.0wtZn (SZ) alloys are commonly lead-free solders for electronic packaging. For an advanced diffusion barrier Ni-xPd alloy application in electronic packaging, the liquid/solid reaction couple techniques have been used to investigate the interfacial reactions in Sn and SAC reacted with Ni-xPd. The reaction mechanism and reaction phase in the Sn/Ni-xPd and SAC/Ni-xPd systems were determined in this study.

2. Methods
The Ni-xPd (x=0, 0.5, 1.5, 3.0 wt.%) alloys were prepared by arc melting furnace. The liquid/solid reaction couples of the Sn/Ni-xPd, SAC/Ni-xPd and SZ/Ni-xPd were reacted at 240, 270, 300 and 330°C for 10, 40, 60, 120 and 300 min.
Scanning Electron Microscopy (SEM) were used to examine the interfacial morphology. The IMCs are then observed using energy dispersive X-ray spectrometer (EDS) mixed binary phase diagram for compositional analysis and interfacial morphology. IMC thickness were observed using SigmaScan Pro5.0. Five data points from each aging condition were collected to calculate the average thickness.

3. Expected Results
The Ni$_3$Sn$_4$ phase was formed in the Sn/Ni-$x$Pd couples. For the SAC/Ni-$x$Pd couples, the (Cu,Ni)$_6$Sn$_5$ and (Ni,Cu)$_3$Sn$_4$ phases were formed at 240°C. When the aging temperatures were increased to 270, 300 and 330°C, the (Cu,Ni)$_6$Sn$_5$ and (Ni,Cu)$_3$Sn$_4$ phases were formed at the interface for 10 min, and the (Ni,Cu)$_3$Sn$_4$ phase was observed for 40 min, 1,2 and 5 h. In the SZ/Ni-$x$Pd couples, the Ni$_5$Zn$_{21}$ phase was formed at the interface. The results indicated that the Pd addition into the Ni substrate would not change the IMCs in all solder/Ni-$x$Pd couples. However, the Pd addition would be inhabited the IMC growth. For these three couples, the IMC thickness was increased with the increase of reaction times and temperatures. The IMC thickness was also proportional to the square root of the reaction time. It meant that the reaction mechanism for all couples was diffusion controlled.

Keywords: intermetallic compound; lead-free solders; Ni-$x$Pd alloys; liquid/solid reaction couples; liquid/solid reaction couples
Poster Session (2)

Chemical Sciences (2)/ Biological Sciences (1)/

Computer Science (1)

Wednesday, May 11, 2016  13:30-14:30  Room 1008

ICCBES-1277
Thermal Stability Analysis of Various Cathode Materials of Lithium-Ion Battery Reacted with Ethylene Carbonate
Shr-Jia Jiang | National United University
Yih-Shing Duh | National United University
Yu-Ling Chen | National United University
Chen-Shan Kao | National United University

ICCBES-1281
First total Synthesis of Ganglioside DSG-A with Neuritogenic Activity
Yu-Fa Wu | Chung Yuan Christian University
Yow-Fu Tsai | Chung Yuan Christian University

ICCBES-1290
CO$_2$-Rice Husk Co-Gasification for the Syngas Production
Alex C.-C. Chang | Feng Chia University
Yu-Chun Chan | Feng Chia University
Chunmin Liu | Feng Chia University

ICCBES-1291
Acetone-Butanol-Ethanol Fermentation by Corn Cob Hydrolysate
Alex C.-C. Chang | Feng Chia University
Yu-Chun Chan | Feng Chia University
Chunmin Liu | Feng Chia University
Hsin-Yi Chou | Feng Chia University
ICCBES-1314
Synthesis, Characterisation and Antimicrobial Activities of Metal Complexes Derived from Schiff Base
Bajirao Bhila Ahire | Savitribai Phule Pune University
Shantaram S. Gunjal | Savitribai Phule Pune University

ICCBES-1335
Effects of pH and Temperature on the Structure of Precipitated Calcium Carbonates for CO₂ Utilization via Mineral Carbonation
Ribooga Chang | Gwangju Institute of Science and Technology
Youngjune Park | Gwangju Institute of Science and Technology

ICCBES-1186
Spectrofluorimetric Characterization of Mixed Micelles Formed By Triton X-100 and Cationic Gemini Surfactant in Aqueous Solution
Halide Akbaş | Trakya University
İkbal Sarıkaya | Karadeniz Technical University
Sinem Kasapoğlu | Trakya University
Mesut Boz | Trakya University
Alper Dikmen | Trakya University

ICCBES-1121
Combination with Gefitinib and Curcuminoids Enhanced Two Kinds of Programmed Cell Death (Autophagic and Apoptotic Cell Death) in Human Oral Squamous Cell Carcinoma SAS Cells
Yung-Ting Hsiao | China Medical University
Ming-Ching Kao | China Medical University
Fu-Shin Chueh | Asia University
Jing-Gung Chung | China Medical University

ICCBES-1122
Apoptosis Induced by Benzyl Isothiocyanate and Phenethyl Isothiocyanate in Human Lung Cancer NCI-H460 Cells with or without Gefitinib-Resistance through Caspases Activation and Regulation of Mitochondrial-Dependent Signaling Pathway
Jing-Gung Chung | China Medical University
Mei-Due Yang | China Medical University
Fu-Shin Chueh | Asia University
ICCBES-1125
Combined Effects of Casticin and 5-Fu on the Growth Inhibit of WEHI-3 Cells In Vitro
Zheng-Yu Cheng | China Medical University
Jing-Gung Chung | China Medical University

ICCBES-1126
Combinational Treatment of All Trans Retinoic Acid (ATRA) and Bisdemethoxycurcumin (BDMC) Induced Apoptosis in Liver Cancer Cells
Ting-Yi Huang | China Medical University
Wen-Wen Huang | China Medical University
Jing-Gung Chung | China Medical University

ICCBES-1142
Analysis of Antioxidant Activity to Peptides Extracted from Tenebrio Molitor Larvae
Sam Woong Kim | Gyeongnam National University of Science and Technology
Woo Young Bang | Environmental Research Complex
Mi Ra Yang | Gyeongnam National University of Science and Technology
Tae Wan Kim | Gyeongnam National University of Science and Technology
Il-Suk Kim | Gyeongnam National University of Science and Technology
Chul Wook Kim | Gyeongnam National University of Science and Technology
Jae Young Kim | Gyeongnam National University of Science and Technology
Jung Seok Choi | Gyeongnam National University of Science and Technology
Jeongim Ha | Gyeongnam National University of Science and Technology
Eun Mi Lee | Gyeongnam National University of Science and Technology

ICCBES-1143
Mechanisms of Leukemic T Cell’s Resistance to Proteasome Inhibitor Bortezomib
Fu-shin Chueh | Asia University
Fu-Yu Chueh | Chang Gung University
Chao-Lan Yu | Chang Gung University

ICCBES-1147
Research Tournefortia Sarmentosa Chemical Analysis of the Anti-Prostate Cancer
Chia-hsien Lin | China Medical University
Yueh-Hsiung Kuo | China Medical University
Jing-Gung Chung | China Medical University
Chao-Lin Kou | China Medical University
ICCBES-1156
Genistein Combined with L-Asparaginase Induced Human Leukemia HL-60 Cell Apoptosis
Yin-Chen Hsiao | China Medical University
Jing-Gung Chung | China Medical University

ICCBES-1159
Cantharidin Induces Apoptosis and Autophagy in U2-OS Human Osteosarcoma Cells
Chia-Ching Chen | China Medical University
Jing-Gung Chung | China Medical University

ICCBES-1166
Co-Delivery of siRNA and Plasmid Using PEI Polymer Incorporating γ-PGA for Osteosarcoma Cancer Therapy
Shu Fen Peng | China Medical University
Wen Wen Huang | China Medical University
Hung Kun Hsu | National Tsing Hua University

ICCBES-1198
Combination with 5-Fluorouracil and Fisetin Promoted Cell Apoptosis in Human Gastric Cancer AGS Cells
Ying-Ru Huang | China Medical University
Shu Fen Peng | China Medical University
Jing-Gung Chung | China Medical University

ICCBES-1205
Rat’s Growth and Change of Intestinal Microbiota by Supply of Beechwood Creosote
Jae Young Kim | Gyeongnam National University of Science & Technology
Jeong A Kim | Gyeongnam National University of Science & Technology
Da Yoon Yu | Gyeongnam National University of Science & Technology
Yeon Hee Hong | Gyeongnam National University of Science & Technology
Kwang Keun Cho | Gyeongnam National University of Science & Technology
In Sung Kim | Gyeongnam National University of Science & Technology
Chul Wook Kim | Gyeongnam National University of Science & Technology
Tae Wan Kim | Gyeongnam National University of Science & Technology
Eun Mi Lee | Gyeongnam National University of Science & Technology
Sam Woong Kim | Gyeongnam National University of Science & Technology
Jung Seok Choi | Gyeongnam National University of Science & Technology
Jeongim Ha | Gyeongnam National University of Science & Technology
ICCBES-1215
Enhanced Apoptosis Effects by Nanoparticles Composed of Novel Surfactant and PLGA/Curcumin on Non-Small Cell Lung Cancer
Hao-Yi Suen | China Medical University
Hung-Kun Hsu | National Tsing Hua University
Chun-Cheng Lin | National Tsing Hua University
Shu Fen Peng | China Medical University

ICCBES-1222
Effects of Coenzyme Q0 on Non-Alcoholic Steatohepatitis
Yu-Wen Chi | China Medical University
Wai-Shan Chung | Chang Gung Memorial Hospital
Wen-Wen Huang | China Medical University

ICCBES-1325
Identification of a Synonymous SNP in the FTL Gene and its Association with Meat Quality Traits
Tae Wan Kim | Gyeongnam National University of Science & Technology
Eun Mi Lee | Gyeongnam National University of Science & Technology
Jung Hye Hwang | Gyeongnam National University of Science & Technology
Eun-Jung Kim | Gyeongnam National University of Science & Technology
Seul Gi Kwon | Gyeongnam National University of Science & Technology
Da Hye Park | Gyeongnam National University of Science & Technology
Deok Gyeong Kang | Gyeongnam National University of Science & Technology
Il-Suk Kim | Gyeongnam National University of Science & Technology
Jae Young Kim | Gyeongnam National University of Science & Technology
Sam Woong Kim | Gyeongnam National University of Science & Technology
Jung Seok Choi | Gyeongnam National University of Science & Technology
Jeongim Ha | Gyeongnam National University of Science & Technology
Chul Wook Kim | Gyeongnam National University of Science & Technology
ICEAI-1086
Observation of Skin Inflammation Process with Optical Coherence Tomography
Tsung-Lin Tsai | Chang Gung University
Feng-Yu Chang | Chang Gung University
Chun-Chieh Wang | Chang Gung Memorial Hospital
Tzu-Hao Hsiung | Chang Gung University
Meng-Tsan Tsai | Chang Gung University
Bo-Huei Huang | Chang Gung University
Yan-Jyun Hu | Chang Gung University

ICCBES-1035
Inhibition of X-Ray Repair Cross-Complement Group 1 (XRCC1) Expression by Curcumin Enhances Cisplatin-Induced Cytotoxicity in Human Lung Cancer Cells
Jyh-Cheng Chen | National Chiayi University
Tai-Jing Wang | National Chiayi University
Yun-Wei Lin | National Chiayi University
Hao-Yu Zheng | National Chiayi University
Wen-Ching Chen | National Chiayi University

ICCBES-1058
The Mechanisms of Nicotine-Induced Chemoresistance through Stat3 Mediated Autophagy and Glycolysis in Human Bladder Cancer Cells
Rong-Jane Chen | National Cheng Kung University
Ying-Jan Wang | National Cheng Kung University

ICCBES-1076
The CHAC1-Inhibited NOTCH3 Pathway Involves in Temozolomide-Induced Glioma Cytotoxicity
Peng-Hsu Chen | Taipei Medical University
Kuo-Hao Ho | Taipei Medical University
Ku-Chung Chen | Taipei Medical University

ICEAI-1018
Electricity Consumption Analysis Using a State-Based Data Mining Approach
I-Chin Wu | Fu-Jen Catholic University
Tzu-Li Chen | Fu-Jen Catholic University
Guan-Qun Hong | Fu-Jen Catholic University
Tzu-Chi Liu | Industrial Technology Research Institute
Yen-Ming Chen | Industrial Technology Research Institute
ICCBES-1277

Thermal Stability Analysis of Various Cathode Materials of Lithium-Ion Battery Reacted with Ethylene Carbonate

Yih-Shing Duh\textsuperscript{b}

Department of Occupational Safety and Health, Jen-Teh Junior College of Medicine, Nursing and Management, Taiwan, ROC

\textsuperscript{b} Department of Safety Health and Environmental Engineering, National United University, Taiwan, ROC

E-mail address: yihshingduh@yahoo.com.tw

Yu-Ling Chen, Shr-Jia Jiang, and Chen-Shan Kao\textsuperscript{*}

Department of Safety Health and Environmental Engineering, National United University, Taiwan, ROC

E-mail address: jcsk@nuu.edu.tw

Abstract

Lithium-ion batteries have been used widely since 1990s however overheating, fires and other accidents result in personal injury from time to time. Many potential thermal hazards have been proposed but few studies indicated that composition of cathode materials and electrolytes might play important roles.

Differential scanning calorimetry (DSC) and confinement tests are performed under a programmed rate of heating mode for measuring exothermic behaviors of various cathode materials reacted with ethylene carbonate (EC) which are commonly used in lithium-ion battery. Characteristics of thermal runaway hazards such as onset temperature, heat flow, reaction heat, peak temperature, maximum pressure, maximum self-heat rate, etc. are assessed.

Cathode materials, i.e., lithium iron phosphate (LiFePO\textsubscript{4}), lithium manganese oxide (LiMn\textsubscript{2}O\textsubscript{4}), lithium nickel manganese cobalt oxide (LiNi\textsubscript{1/3}Mn\textsubscript{1/3}Co\textsubscript{1/3}O\textsubscript{2}, NMC333), (LiNi\textsubscript{0.8}Co\textsubscript{0.2}O\textsubscript{2}), LiNi\textsubscript{0.5}Mn\textsubscript{0.3}Co\textsubscript{0.2}O\textsubscript{2}, NMC532), etc. are reacted with EC and accessed, respectively. Results indicate that the highest self-heat rate occurred at the reaction of LiNi\textsubscript{0.8}Co\textsubscript{0.2}O\textsubscript{2} with EC and LiFePO\textsubscript{4} with EC obtained the smallest self-heat rate. In summary LiFePO\textsubscript{4} owns itself a much better thermal stability than other cathode materials. Disregarding the influences of lithium salt and binder equipped in lithium-ion batteries in this study, simplified reactive systems between lithium transition metal oxides with EC could be clearly investigated.

Keywords: lithium-ion battery, cathode material, thermal stability, ethylene carbonate
ICCBES-1281
First total Synthesis of Ganglioside DSG-A with Neuritogenic Activity

Yu-Fa Wu, Yow-Fu Tsai*
Department of Chemistry, Chung Yuan Christian University, Taiwan
E-mail address: tsaiyofu@cycu.edu.tw

1. Introduction
Ganglioside DSG-A (1), isolated from the ovary of the sea urchin *Diadema setosum*, displays neuritogenic activity toward the rat pheochromocytoma cell line PC-12 cell in the presence of nerve growth factor (NGF) with an effect (40.8%) greater than that of the mammalian ganglioside GM1 (25.4%). Herein, we wish to report a total synthesis of DSG-A with an efficient methodology for a gram-scale (50 g) synthesis of the phytosphingosine moiety.

2. The Retrosynthetic Analysis of DSG-A (1)
We intend adopting a [1 + 1 + 2] strategy combining the chemoselective glycosylation to assemble the four building blocks, including the sialyl donor 4 or 5, the glucose derivative 6, the succinimidyl acetoxyester 7, and the phytosphingosine derivative 8.

3. Conclusion
We have finished the first total synthesis of ganglioside DSG-A by employing a [1 + 1 + 2] synthetic strategy and chemoselective glycosylation. The glycosylation of sialyl donor 5 with glucosyl acceptor 6 and the conjugation of the synthesized disaccharide 2a with the protected phytoceramide 3 resulted in both excellent yield and stereoselectivity. In addition, we have also developed an efficient method that can be applied to a large scale synthesis of phytosphingosine (50 g) in an efficient manner.

Keywords: ganglioside, neuritogenic activity, chemoselective glycosylation, phytoceramide
ICCBES-1290

CO₂-Rice Husk Co-Gasification for the Syngas Production

Alex C.-C. Chang *,b
Chemical Engineering Department, Feng Chia University, Taiwan
b Green Energy Development Center, Feng Chia University, Taiwan
E-mail address: acchang@fcu.edu.tw

Yu-Chun Chan, Chunmin Liu
Chemical Engineering Department, Feng Chia University, Taiwan

1. Background/ Objectives and Goals

Recently, the global warming effects and energy supplies issues have been drawn more and more attentions around the world. Biomass is a potential energy resources and there are several pathways (e.g. physical, thermal, chemical, and biological conversion) to generate energy from biomass. By the preceding methods, biomass could be converted to heat, electricity, solid fuels (coal), liquid fuels (bio-oil, methanol and ethanol) and gaseous fuels (hydrogen and syngas), respectively. In this study, the effects of the CO₂-rice husk co-gasification for syngas production was investigated by a lab-scale gasifier.

2. Methods

The Taguchi method by the L9 orthogonal array was used to determine the optimum experimental conditions. The gasification temperature (T), equivalent ratio (ER), ratio of steam to biomass (S/B) and the ratio of CO₂ to O₂ (CO₂/O₂) in the sweeping agent were applied to the orthogonal array with respect to three different level of the operating conditions.

3. Expected Results/ Conclusion/ Contribution

Under the condition without steam fed to the gasifier, the yield of H₂ and CO were increased with increment air fed to the reactor. However, the higher air flow rate would also increase the gaseous flow speed passing through the reactor. The yield of the desired products were also decreased. The highest yield of syngas was 3.8906L/min at ER=0.27, CO₂/O₂=0.3 and 1000°C. At the condition of ER=0.27, the increment of steam feeding rate did not enhance the yield of the desired product. However, the yield of the syngas can be increased with CO₂ blending into the sweeping gas stream. By combing all the designing parameters, 1,000°C, ER = 0.27, S/B=0, and CO₂/O₂ = 0.5 attained 8.3245L/min, the highest yield of syn-gas. The presence of CO2 in the sweeping agent will also enhance Boudouard reaction (C + CO₂ → CO) and water gas shift reaction (CO₂ + H₂O → CO + H₂) to increase the yield of the syn-gas. The results also verified that the yield of the syn-gas could be increased with CO₂ blending into the feed stream.
Keywords: biomass gasification, CO₂ co-gasification, Taguchi method, syn-gas production, experimental design

Acknowledgements

The authors would thank for the financial support for this study from the Ministry of Science and Technology in Taiwan, ROC (under contract No. MOST103 - 2221 - E - 035 - 087MY2) and Feng Chia University (under contract No. FCU-08G27201, FCU-09G27102).
ICCBES-1291
Acetone-Butanol-Ethanol Fermentation by Corn Cob Hydrolysate

Alex C.-C. Chang *, b
Chemical Engineering Department, Feng Chia University, Taiwan
b Green Energy Development Center, Feng Chia University, Taiwan
E-mail address:acchang@fcu.edu.tw

Yu-Chun Chan, Hsin-Yi Chou, Chunmin Liu
Chemical Engineering Department, Feng Chia University, Taiwan

1. Background/ Objectives and Goals
Fossil fuel is still today’s major energy resource and causes global atmospheric pollution problems during its usage. Seeking for the alternative energy resource is the key issue for current energy research. Bioenergy production from non-food related feed stock by the thermal-chemical or the biological processes can be a good route for the alternative energy production. An integration process for acetone-butanol-ethanol (ABE) fermentation by the corn-cob hydrolysate was proposed in this study.

2. Methods
The corn-cob hydrolysate was prepared by the biological process, hydrolyzed by T. reesei ATCC 26921(SIGMA), or the thermal chemical process, diluted acid catalyzed hydrolysis at 150°C following the over-lime treatment to remove the potential inhibitors. Clostridium acetobutylicum ATCC824 was used as the micro-flora for the acetone-butanol-ethanol fermentation process at 37°C, and the total sugar concentration of 70, 60, and 50 g/L and pH = 6.5, 6.0, and 5.5, respectively. The fermentation was originally studied in the batch mode. Further studied was focused in the CSTR operation.

3. Expected Results/ Conclusion/ Contribution
The results of experimental optimization showed the highest acetone, butanol, and ethanol concentration of 34.43, 3.89, and 0.29 g/L, respectively, by using 7.5% (w/v) corncob biomass hydrolyzate and modified P2 medium for fermentation. The developed process is easy in operation, simple and does not involve separate hydrolysis with acid and enzyme, and fermentation for production of butanol from lignocellulosic biomass. Our results demonstrate the feasibility of one pot process for butanol production from lignocellulosic biomass.

Furthermore, a continuous flow stirred tank reactor (CSTR) was used to explore the effects of HRT (12 and 24 hours), pH (5.5 and 6.0) and different types of hydrolysate (enzymatic hydrolysate and dilute acid hydrolysate) on ABE production.
The results showed that the optimal ABE yield and ABE production rate was 0.12±0.02 mol/mol TSused and 1.84±0.35 g/L/d, respectively, when the CSTR reactor was operated at pH 5.5, total sugar concentration 60 g/L and HRT 24 h with enzymatic hydrolysate.

Keywords: Simultaneous saccharification and fermentation, continuous flow stirred tank reactor, acetone-butanol-ethanol fermentation
ICCBES-1314
Synthesis, Characterisation and Antimicrobial Activities of Metal Complexes Derived from Schiff Base

Bajirao Bhila Ahire
Postgraduate Department of Chemistry, NVPM Arts, Commerce and Science College, India
ahirebb07@rediffmail.com

Shantaram S. Gunjal
Department of Chemistry, K NMS Arts, Science and Commerce College, India

Abstract
The study report reveals the synthesis of Schiff bases as tetra dentate ligands forms complexes with various metal ions. The Schiff base, bis (2-hydroxybenzaldehyde) 4-4’diaminodiphenyl ether, was synthesized and its complexes with Bi(III),Sn (II),Fe(III),Zn(II),Cd (II),and Zr (II) were also synthesized. The resulting products were found to be solids with yellow orange color. They were characterized by using solubility, melting point, decomposition temperature, infrared (IR), ultra violet (UV) spectroscopy. The Schiff base and its complexes were evaluated in a view of biological potential of selected antibacterial and antifungal activities using reference standard and different stains of bacterial and fungal organisms. The certain complexes exhibited significant antimicrobial properties. These complexes were also tested for their in vitro antimicrobial activities against some bacterial strains to assess their inhibiting potential. The activities shown by these complexes were compared with standard drugs. This study is used as a tool to solve the health hazards of living beings.

Key words: Schiff base, complex, antimicrobial activity.

Introduction
When an aldehyde or ketone reacts with a primary amine then a Schiff base is formed. It is a compound containing group –N=CH- called imine. [1]. It imports in determining the mechanism of rasemination and transamination reactions in many biological systems. [2] They can be synthesized from aldehydes and aromatic amines by nucleophilic addition forming hemiaminal, followed by dehydration giving an imine. Many Schiff base compound represented by the various structural formulae are known. They can be readily prepared by condensation of substituted aldehydes or ketones with suitable amines under different conditions. The reactants can be added into a simple alcoholic solvent, viz methanol or ethanol, and allowed to react in the presence or absence of external heat with stirring or refluxing. On the other hand reactants may be added into a non-alcoholic solvent, viz toluene and allowed to provide external heat or may not. Water is generated in the reaction; it is removed by any suitable method.
Microwave irradiation was used to synthesize the complexes [3]. The transition metal ions have special and unique chemical activity, optical and magnetic properties. A complex contains a transition metal ion surrounded by ligands [4]. Many organic groups contain one or more donor atoms [5]. They are having charge or neutral. In a complex, usually a certain number of ligands surround a metal ion in a certain geometrical fashion [6]. Each ligand shares a pair of electrons with the metal. The special arrangement of donor atoms around the metal atom or ion determines the geometry of the complex. [7] The ability of certain ligands (Schiff base) to remain intact in the inner coordination sphere or it dissociates away from the inner coordination sphere. This determines their stability. The complexes which have bis, tris, tetrakis groups are much stable than monodentate ligand [8, 9]. Many chemical compounds are biosynthetically or synthetically produced, which either destroy or suppress the growth or metabolism of a variety of microscopic or submicroscopic microorganism. On the basis of their primary activity, they are more specifically called antibacterial, antifungal, anti parasitic or antiviral agents. Antibacterial agents destroy particular harmful microorganism [10]. The thousands of antimicrobial agents, metal nanoparticles are used as antiviral agents [11]; only a small number of agents are safe chemotherapeutic agents, effective in controlling infectious diseases in animals, and humans [12]. A much larger number are used in almost every phase of human activity: in food preservation, and water, skin, and air disinfection. Many heavy metal cations such as Pb$^{2+}$, Hg$^{2+}$, Cu$^{2+}$, Ni [13,14,15]were synthesized and have antimicrobial activities [16], but they are very toxic to other living organisms, thus making them unsuitable for treating infectious diseases biologically important. Pyridoxal phosphate is a coenzyme; it is carried out on the side chain of a lysine residue of the enzyme. Lysine has a long flexible side chain of four CH2 groups ending with a primary amine (NH2). This group forms a Schiff base, Which was characterized by spectroscopic methods.[17]

The present research work consists of synthesis and characterization of complexes containing Schiff base and study of antimicrobial activity. It is known that metal ions in the complexes are involved in biological processes, through bonding to the hetero atoms of the heterocyclic molecules (Erwin and Omoshile, 1995). Various complexes of cobalt, nickel and copper were reported to have antimicrobial activities (El-Ayaan and Abdel-Aziz, 2005; Sonmez et al., 2006), antifungal (Singh and Dash, 1998), antitumor (Desai et al. 2001) and herbicidal activities (Samadhiya and Halve, 2001). Schiff base continue to occupy a vital position as ligands in metal coordination chemistry even almost many years since its discovery. [18, 19,20] Moreover, the incorporation of transition metal into Schiff bases enhances the biological activity [21]

**Experimental**

The chemicals FeCl$_3$.6H$_2$O, Bi (NO$_3$)$_3$.5H$_2$O , CuCl$_2$ . 2H$_2$O , ZnCl$_2$ CdCl$_2$,HgCl$_2$ , Co(NO$_3$)$_2$, 6H$_2$O,SnCl$_2$, ZrOCl$_2$, 2- Hydroxybenzaldehyde ,Diethylmalonate, hydrazine hydrate,
ethyl alcohol DMSO, (LOBA Chem.) double distilled, deionised water were used for this research work.

**Preparation of Schiff Base Bis (2-HydroxyBenzaldehyde) 4-4’DiaMinodiphenyl Ether (1c):**
A mixture of 2- Hydroxybenzaldehyde (0.02 mol) was added to a solution of 4, 4’-diaminodiphenyl ether (0.01 mol) in ethanol (40.00 ml) with constant stirring at room temperature for three-four hours to get yellow product. It was then filtered and washed with petroleum ether followed by crystallization from ethanol. The excess solvent was removed on rota evaporator, to give pure Schiff base. Its purity was checked by T.L.C. and M.P. (Scheme 1)

![Schiff base preparation](image)

**Synthesis of the Metal Complexes**
1) A mixture of Bismuth nitrate (0.1 mole) and Schiff base (0.2 moles) in ethanol was refluxed for 6-8 hours and kept for overnight. It was then filtered and washed with ethanol followed by ether and dried under reduced pressure.

2) The 0.1mole solutions of salts viz FeCl₃,6H₂O, Bi (NO₃)₃.5H₂O, CuCl₂ • 2H₂O, ZnCl₂ CdCl₂,HgCl₂, Co (NO₃)₂, 6H₂O,SnCl₂, ZrOCl₂ and Schiff base (0.2 moles) in ethanol were mixed and refluxed for 6-8 hours. The resulting solutions were kept for overnight. Then, they
were filtered and washed with ethanol followed by ether and dried under reduced pressure. The corresponding metal complexes were obtained. The Schiff base complexes is presented as,

![Figure 1: proposed structure of the complex](image1)

In order to examine the antimicrobial activity, the Schiff base and its metal complexes were evaluated for their in vitro antibacterial activity against Staphylococcus aureus ATCC 25923, Pseudomonas aruginosa ATCC27853, and Escherichia coli ATCC25922 using Gentamycin as a reference standard by disk diffusion method (Kirby-Bauer). Antibacterial and antifungal activity was evaluated against Candida sp. by using Nystatin as a standard reference. The present report shows that the Schiff bases prepared has less or negligible activity. The synthesized metal complexes [1c(C), 1c (D)] shows moderate antibacterial activity. The zone of inhibition of microorganisms are summarized in the Table 3.

Antimicrobial Activity

In order to examine the antimicrobial activity, the Schiff base and its metal complexes were evaluated for their in vitro antibacterial activity against Staphylococcus aureus ATCC 25923, Pseudomonas aruginosa ATCC27853, and Escherichia coli ATCC25922 using Gentamycin as a reference standard by disk diffusion method (Kirby-Bauer). Antibacterial and antifungal activity was evaluated against Candida sp. by using Nystatin as a standard reference. The present report shows that the Schiff bases prepared has less or negligible activity. The synthesized metal complexes [1c(C), 1c (D)] shows moderate antibacterial activity. The zone of inhibition of microorganisms are summarized in the Table 3.

Results and Discussion
The method described in this research work is a simple to direct synthesis the ligands (1a-1f) and complexes [1c (A)-1c (F)]. The products obtained are yellow, pale yellow, orange and white colored and are well soluble in DMSO and DMF solvents, Molar conductance were measured the complexes are electrolyte. Complexes are air stable. The ligands (1a-1f) and complexes [1c (A)-1c (F)] were characterized. Metal complexes shows activity towards microorganisms [10].

Figure 3. Infrared spectrum of Schiff base
Infrared spectra of Schiff base prepared and their metal complexes were done by IR Spectrophotometer (Shimadzu). The infrared spectral data is summarized as, 1c: IR (KBr, cm$^{-1}$) 1618 (C=N), 3448 (OH), 1280 (C-O). The absorption bands are found to be sharp.

Table 1 Analytical and physical data of the compound under study.

<table>
<thead>
<tr>
<th>Sr.No.</th>
<th>Schiff base</th>
<th>Empirical Formula</th>
<th>Molecular Weight</th>
<th>Colour</th>
<th>Melting Point, °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1a</td>
<td>C$<em>{17}$H$</em>{16}$N$<em>{4}$O$</em>{2}$</td>
<td>308.304</td>
<td>White</td>
<td>205</td>
</tr>
<tr>
<td>2</td>
<td>1b</td>
<td>C$<em>{17}$H$</em>{16}$N$<em>{4}$O$</em>{2}$</td>
<td>308.304</td>
<td>Pale Yellow</td>
<td>221</td>
</tr>
<tr>
<td>3</td>
<td>1c</td>
<td>C$<em>{26}$H$</em>{20}$N$<em>{3}$O$</em>{3}$</td>
<td>408.409</td>
<td>Yellow</td>
<td>220</td>
</tr>
<tr>
<td>4</td>
<td>1d</td>
<td>C$<em>{30}$H$</em>{30}$N$_{4}$O</td>
<td>462.533</td>
<td>Pale Yellow</td>
<td>222</td>
</tr>
<tr>
<td>5</td>
<td>1e</td>
<td>C$<em>{15}$H$</em>{26}$N$_{6}$O</td>
<td>354.407</td>
<td>Pale Yellow</td>
<td>242</td>
</tr>
<tr>
<td>6</td>
<td>1f</td>
<td>C$<em>{15}$H$</em>{26}$N$_{6}$O</td>
<td>354.407</td>
<td>Orange</td>
<td>200</td>
</tr>
</tbody>
</table>
The spectroscopic analysis confirmed the proposed structures for these complexes. Antibacterial data have shown that the synthesized schiff base has negligible activity than complex compounds. According to chelation theory, ligands have less biological activity than metal complexes. They have significant biological activity against the tested microorganisms. Activity was shown only by Zn, Cd complexes. The main group elements used was not showing such results.

Acknowledgement
I wish to gratefully acknowledge the University Grants Commission, New Delhi for financial assistance. B.C.U.D., S.P.Pune University for necessary help. Hon’ble Govindrao Holkar, Secretary N.V.P.Mandal, Lasalgaon, Principal Dr.Dinesh P. Naik, Dr.Sureshchandra G.Kulkarni (Pune), Dr.Pradipkumar .S.Shah and my colleagues for their constant help and encouragement.

References
4. Xishi Tai, Xianhong Yin, Qiang Chen and Minyu Tan, 2003, Synthesis of Some Transition Metal Complexes of Novel Schiff Base Ligand Derived from 2,2’- Bis(p- Methoxy Phenylamine) and Salicylic Aldehyde, *Molecules*, 8, 439-443.
14. Shayma, A.S., Yang F., Abbas A.S., 2009 Synthesis and characterization of mixed ligand complexes of 8-hydroxyquinoline and o-hydroxybenzylidene-1-phenyl-1,2,3-dimethyl-4-amino-3-pyrazolin-5- on with Fe(II), Co(II), Ni(II) and Cu(II) ions, European Journal of scientific research Vol.33 No.4.


ICCBES-1335
Effects of pH and Temperature on the Structure of Precipitated Calcium Carbonates for CO₂ Utilization via Mineral Carbonation

Ribooga Chang, Youngjune Park*  
School of Environmental Science and Engineering,  
Gwangju Institute of Science and Technology (GIST), Republic of Korea  
young@gist.ac.kr

1. Background
Due to the increasing use of fossil fuels and the deepening global climate change, development of capturing, utilizing and storing carbon dioxide (CCUS) technologies have been the focus of recent research in the energy and environment field. Once CO₂ is captured from flue gas stream, it can be converted into value-added materials through CO₂ utilization schemes. Among the CO₂ utilization options, carbon mineralization could offer distinct beneficial roles because; i) CO₂ is easily converted into mineral carbonates reacting with Ca or Mg sources, which can be obtained with ease from naturally occurring silicate minerals or various industrial wastes, ii) CO₂ can be stored as a solid form of carbonates that is permanent and has no chance to leakage, and iii) the precipitated carbonates, i.e. CaCO₃ and MgCO₃, are commercially valuable materials, and thus they can be used in various industrial areas such as plastics, paper, glass, cement, rubber, paint, construction materials, etc. In this study, we investigated the effects of pH and temperature on the structural behavior of precipitated calcium carbonates, aiming to control their atomic and morphological structures. Power x-ray diffraction (PXRD) and attenuated total reflectance (ATR) FT-IR spectroscopic analyses were performed.

2. Methods
In order to investigate the effects of pH and temperature on the structural properties of calcium carbonates, precipitated calcium carbonates were synthesized using model chemicals of Ca(NO₃)₂ and K₂CO₃ varying pH conditions from 7 to 11 at 20 and 80 °C, respectively. The pH conditions were adjusted changing stoichiometric mixing ratio between Ca(NO₃)₂ and K₂CO₃. For example, carbonate sample precipitated at pH 7.41 was prepared by mixing 100 ml of 0.5 M Ca(NO₃)₂ solution with 100 ml of 0.5 M K₂CO₃ solution at 20 °C for 30 min at a constant stirring speed of 500 rpm. During the mixing, the mixture was mounted on a combined hot-plate magnetic stirrer device. After then, the precipitate was collected by filtration through a filter paper (0.45 μm) in a Büchner funnel. Finally the powder sample was obtained after drying in an oven at 60°C for 24 hr. All the samples were analyzed using XRD, SEM, and ATR FT-IR for the structural characterizations without further treatment.

3. Result
In a thermodynamics point of view, among the possible crystalline structures of CaCO₃, calcite (trigonal \textit{R32/c}) is known as the most stable structure at the precipitated conditions conducted this study. However, less stable structures of vaterite (hexagonal \textit{P63/mmc}) and aragonite (orthorhombic \textit{Pmcn}) were found and it was confirmed that their relative concentrations were dramatically changed as a function of the precipitated pH and temperature conditions. At lower temperature condition (20 °C), all the samples precipitated at pH ranging from 7 to 11 included two components of vaterite and calcite. Interestingly, it was found that the relative concentrations of vaterite were always higher than that of calcite in all the pH conditions investigated in this study.

In particular, the concentration of vaterite increased up to ~90% at pH 11. At higher temperature condition (80 °C), however, tertiary mixture of calcite, vaterite and aragonite was observed, and aragonite became major component as pH increased. Morphological structures of the samples were also investigated and dramatic structure changes were observed. The results imply that pH and temperature conditions can play critical roles to control the atomic and morphological structures of CaCO₃, and one can expect the tailor-synthesized carbonates via optimizing the parameters.

Keywords: Carbon Capture and Storage, Mineral Carbonation, Carbon Dioxide, Precipitated Calcium Carbonate, Crystallization
ICCBES-1186
Spectrofluorimetric Characterization of Mixed Micelles Formed By Triton X-100 and Cationic Gemini Surfactant in Aqueous Solution

Halide Akbaş*
Department of Chemistry, Faculty of Sciences, Trakya University, Turkey
E-mail address: hakbas34@yahoo.com

Sinem Kasapoğlu
Department of Chemistry, Faculty of Sciences, Trakya University, Turkey
sinem.kasapoglu22@gmail.com

Mesut Boz
Department of Chemistry, Faculty of Sciences, Trakya University, Turkey
mesutboz@trakya.edu.tr

Alper Dikmen
Department of Chemistry, Faculty of Sciences, Trakya University, Turkey
dikmenalper429@gmail.com

İkbal Sarıkaya
Department of Chemistry, Faculty of Sciences, Karadeniz Technical University, Turkey
ikbalsrkya@gmail.com

Abstract
Spectrofluorimetric experiments have been performed to determine the critical micelle concentration (CMC) and the aggregation number \(N_{agg}\) of pure and mixed surfactant solutions at 25°C. A novel cationic Gemini surfactant with amide functional group have been synthesized, purified and characterized in our laboratory.

Pure and mixed micellar system of cationic Gemini and non-ionic surfactant (Triton X-100 ) were investigated by using a probe and a quencher under steady-state conditions. The fluorescence measurement is a classical method of studying the critical micelle concentration of surfactants. Pure and mix solutions were prepared different concentration with pyrene. At the all mesurements pyrene concentration was taken consant (2 µM). The CMC values of pure surfactants and mix solutions were determined based on the breakpoint of the fluorescence measurements at 25°C. The concentration corresponding to the breakpoint of the \(I_1/I_3\) concentration was taken as the CMC value. The micellar aggregation numbers \(N_{agg}\) of single and mixed surfactant solutions were determined using Hitachi F-2700 steady-state fluorescence
spectrophotometer at excitation wavelength of 335 nm. Aggregation number values were
determined by keeping $[C_{Surf}]$ at ten times of cationic gemini surfactant’s CMC. Also, using the
graphs of $\ln(I_o/I)$ versus concentration of quencher $[Q]$, aggregation values are calculated for
single and mixed systems.

The CMC values were found as 0.2900 mM for Triton X-100 surfactant and as 0.4250 mM for
pure Gemini surfactant. CMC values have changed between two values for mixed solutions.
The values of aggregation number of mixed surfactant systems were increased with an increase
in Triton X-100 composition. Values of aggregation numbers are found in the range 30-104.
Critical micelle concentration values indicated that there is the mixed micelle formation among
the two surfactants.

Keywords: Cationic gemini surfactant, Critical micelle concentration, mixed micelles, Micelle
aggregation number, Spectrofluorometric studies.
ICCBES-1121
Combination with Gefitinib and Curcuminoids Enhanced Two Kinds of Programmed Cell Death (Autophagic and Apoptotic Cell Death) in Human Oral Squamous Cell Carcinoma SAS Cells

Yung-Ting Hsiao
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: kazafhsiao@gmail.com

Ming-Ching Kao
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: mckao@mail.cmu.edu.tw

Fu-Shin Chueh
Department of Health and Nutrition Biotechnology, Asia University, Taiwan
Email address: fushin@asia.edu.tw

Jing-Gung Chung*
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: jgchung@mail.cmu.edu.tw

1. Background/Purpose:
Greater understanding of the molecular basis of cancer is fostering the development of novel targeted strategies that inhibit specific cancer pathways and key molecules in tumor growth and progression. An important mediator of growth-factor signaling pathways is the epidermal growth factor receptor (EGFR) that activation as the most common even in oral squamous cell carcinoma (OSCC). Here, we showed that human oral squamous cell carcinoma SAS cells have good responses to the tyrosine kinase inhibitor (TKI), gefitinib. In addition, curcumin or its demethylation derivatives can improve the efficiency of gefitinib in the SAS cells in vitro model.

2. Methods:
We investigated whether or not curcumin or it major forms of curcuminoids combined with gefitinib induced apoptosis or autophagy in SAS cells. We determined the percentage of cell viability, annexin v-positive cells, mitochondrial membrane potential (MMP) levels, calcium production and reactive oxygen species (ROS) expression by flow cytometry. The results from DNA gel electrophoresis assay and DAPI staining indicated DNA damage levels. The results from acridine orange (AO) staining, Monodansylcadaverine (MDC) staining and using GFP-LC3 transgenic cells indicated autophagy phenomenon.
Finally, we used western blotting to indicate apoptosis and autophagy associated protein expression.

3. Results/Conclusions:
After screening 4 cell lines of OSCC, we found SAS cells were insensitive with 3 kinds of curcuminoids. The main reason we suggest curcuminoids induced autophagy to protect cells that decreased drug sensitive in SAS cells. We also indicated that curcuminoids stimulated a certain extent cell apoptosis through DNA damage. However, we found gefitinib could enhanced curcuminoids-induced cell death by autophagic and apoptotic PCD. In summary, our finding may provide more information and novel therapeutic strategies in the treatment of cancer.

Keywords: human oral squamous cell carcinoma, autophagy, apoptosis, curcuminoids, drug combination
ICCBES-1122

Apoptosis Induced by Benzyl Isothiocyanate and Phenethyl Isothiocyanate in Human Lung Cancer NCI-H460 Cells with or without Gefitinib-Resistance through Caspases Activation and Regulation of Mitochondrial-Dependent Signaling Pathway

Jing-Gung Chung*
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: jgchung@mail.cmu.edu.tw

Mei-Due Yang
Department of Surgery, China Medical University Hospital, Taiwan
Email address: d5218@mail.cmuh.org.tw

Fu-Shin Chueh
Department of Health and Nutrition Biotechnology, Asia University, Taiwan
Email address: fushin@asia.edu.tw

1. Background/Purpose:
Chemotherapy, which is one of the medical treatments for cancer, has limited effects to cancer because of its drug resistance. Drug resistance activates the intercellular survival messages and blocks the pathway of death signals. It lead to results in the cancer cells to escape from the drugs cytotoxicity. In general, the existing of molecular and genetic heterogeneity and cancer stem cells are leading to drug resistance. According to the statistics of Ministry of Health and Welfare, lung cancer is in the first place of causes of death in Taiwan. As a result, many targeted therapies are developed. Gefitinib is the first targeted drug approved for human non-small cell lung cancer (NSCLC) treatment. Clinical trails showed that patients with certain clinical and histologic characteristics had higher rates of response and overall survival. Despite excellent clinical response to gefinitib in certain NSCLC patients, nearly all patients who respond initially to gefitinib later develop drug resistance.

2. Methods:
We determined the percentage of cell viability, annexin v-positive cells and caspases activity by flow cytometer. The results from cell morphology change that we observed by microscopy. Further, we used Western blotting to indicate mitochondrial associated protein expression in lung cancer cells.

3. Results/Conclusions:
In this report, we found that benzyl isothiocyanate (BITC) and phenethyl isothiocyanate
(PEITC) inhibited human NSCLC (with or without gefitinib resistance) cell growth by inducing apoptosis in a dose-dependent and time-dependent manners, and activated caspase-3, -8, -9 activities. We also found BITC and PEITC induced cell apoptosis through mitochondrial-dependent signaling pathway in these two kinds of NSCLC cells. Our results demonstrated that BITC and PEITC overcame gefitinib resistance in lung cancer cells. The further understanding of the anti-resistance mechanism of BITC and PEITC would contribute to establish it as a potent lead compound for the synthesis of novel anticancer drugs.

Keywords: benzyl isothiocyanate, phenethyl isothiocyanate, gefitinib resistance, human non-small cell lung cancer, apoptosis.
ICCBES-1125

Combined Effects of Casticin and 5-Fu on the Growth Inhibit of WEHI-3 Cells In Vitro

Zheng-Yu Cheng*
Department of Biological Science and Technology, China Medical University
kaller2826@gmail.com

Jing-Gung Chung
Department of Biological Science and Technology, China Medical UniversityE-mail address: jgchung@mail.cmu.edu.tw

1. Background/ Objectives and Goals
To study the inhibition of WEHI-3 cell viability by two commonly used anti-cancer antitumor agent, casticin (3’,5-dihydroxy-3,4’,6, 7-tetramethoxyflavone) in combination with the fluorouracil (5-FU) and to investigate whether the mechanisms of these drugs are related to inhibition of WEHI-3 cell growth in vitro.

2. Methods
Casticin and fluorouracil (5-FU) were combined using to examine the effect on WEHI-3 cells. The cell viability was determined by flow cytometry assay, In addition, flow cytometric analysis of mitochondrial membrane potential (MMP) levels using immobilized fluorescent substrate on microspheres. The apoptotic associated protein were determined by Western blotting.

3. Expected Results/ Conclusion/ Contribution
Casticin were synergistic with 5-FU to inhibit the growth of WEHI-3 cells and the combinational use both compounds significantly reduced the dosage of each drug for causing cell death .Casticin were synergistic with 5-FU to inhibit WEHI-3 cells. Our results suggesting a novel strategy to combine with both compound to reduce the side effects of clinical use 5-fu. At higher doses, the drugs could induce cell death, while at low does, they suppress cancer cell growth via independent mechanisms, Apparently, further investigations are needed.

Keyword: Combined effects; Growth inhibition; WEHI-3; Fluorouracil (5-FU)
ICCBES-1126
Combinational Treatment of All Trans Retinoic Acid (ATRA) and Bisdemethoxycurcumin (BDMC) Induced Apoptosis in Liver Cancer Cells

Ting-Yi Huang*
Department of Biological Science and Technology, China Medical University
wea584@gmail.com

Wen-Wen Huang, Jing-Gung Chung
Department of Biological Science and Technology, China Medical University
wwhuang@mail.cmu.edu.tw

Jing-Gung Chung
Department of Biological Science and Technology, China Medical University
jgchung@mail.cmu.edu.tw

1. Background/ Objectives and Goals
Liver cancer is one of the most common malignancies and a predominant cause of cancer-related death. Natural products, with stronger antitumor activity and fewer side effects, are potential candidates for pharmaceutical development as anticancer agents. All trans retinoic acid (ATRA) has been shown that Hepatocellular carcinoma (HCC) patients have significantly lower levels of serum retinol than normal subjects and, suggesting that defects on retinoid metabolic pathways could be responsible, or at least related to the hepatic tumor-inducing events. Moreover, Bisdemethoxycurcumin (BDMC) is one of the components of turmeric, has been known to possess biological activities. Due to these activities and potentially different mechanisms of action, when these compounds were used together, It may enhance the bioavailability of these drugs or reduce the side effect. Nevertheless, the effect of ATRA and BDMC in combination on human liver cancer has not been reported. The goal of this study was to find out the synergic cytotoxicity effect of two natural compounds, ATRA and BDMC.

2. Methods
In this study, ATRA and BDMC were chosen for testing and were applied separately and in combination to human liver cancer Hep3B cells. The Flow cytometry assay was used to evaluate cell growth inhibition. Combination index and modified coefficient of drug interaction (CDI) methods were used for evaluation the combination effects of ATRA and BDMC in different ratio and concentration. Apoptosis was evaluated by Sub-G1 development in cell cycle distribution and mitochondrial membrane potential which was assayed by flow cytometry, and signal transduction pathways investigated by Western blotting.
3. Expected Results/ Conclusion/ Contribution

The results indicated that IC50 values of ATRA and BDMC were 150 µM and 25 µM, respectively. The combination of ATRA and BDMC shown the strongest anti-cancer cell proliferation effect at the ratio of 50:15 (ATRA:BDMC, the average CDI value was 0.84). The drugs separately increased cytotoxicity against Hep3B cells in a time and dose dependent manners. And, We also observed ATRA alone didn’t change the ΔΨm level, while BDMC alone or in combination with ATRA significantly decreased the ΔΨm level. Effect of combined treatment with ATRA and BDMC on human liver cancer Hep3B cells is stronger than that of individual treatment, indicating that ATRA and BDMC combinations have potential as anti-liver cancer drugs for further development. Our findings suggested that the combinational treatment might be beneficial for anti-proliferation of Hep3B liver cancer cells through a significant synergy effect, at least in part, through modulation of apoptosis. In the future studies are on going in order to elucidate natural compounds and cellular mechanisms responsible of the activities described.

Keyword: Combination effect, ATRA, BDMC, Hep3B, Apoptosis
ICCBES-1142
Analysis of Antioxidant Activity to Peptides Extracted from Tenebrio Molitor Larvae

Sam Woong Kim
Swine Science and Technology Center,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: swkim@gntech.ac.kr

Woo Young Bang
National Institute of Biological Resources, Environmental Research Complex, South Korea
E-mail address: wybang@korea.kr

Mi Ra Yang
Department of Animal Resources Technology,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: karisto2000@nate.com

Chul Wook Kim
Swine Science and Technology Center,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: cwkim@gntech.ac.kr

Jae Young Kim
Swine Science and Technology Center,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: prirkim@gntech.ac.kr

Tae Wan Kim
Swine Science and Technology Center,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: twkim@gntech.ac.kr

Jeongim Ha
Swine Science and Technology Center,
Gyeongnam National University of Science and Technology, South Korea
E-mail address: jiha@gntech.ac.kr

Jung Seok Choi
1. Background/Objectives and Goals

Insects have been highly evaluated for availability as new food materials in recent years owing to a high protein source and functional potential. We identified the antioxidant activity of peptides extracted from *Tenebrio molitor* larvae to find a new material for functional foods.

2. Methods

*Tenebrio molitor* larvae were powdered by freeze-drying and then extracted by organic solvent, methanol fractionation, and partition. In order to examine function of peptides, the extracted peptides were treated by heat denaturation or proteinase K degradation and then examined for antioxidant activity.

3. Expected Results/Conclusion/Contribution

After extraction from the freeze-dried *T. molitor* larvae with various solvents on time course, the ones, which extracted with water for 5 h and 10 h, showed the highest DPPH activities per total protein and solid, respectively. When the water extract was fractionated depending on methanol concentration, high concentration of methanol led to the reduced level of the high molecular weight proteins and the increased level of the DPPH activity in supernatants, suggesting that the low molecular weight peptides may mediate the antioxidant activity in the supernatant. The most of organic solvents excluding butanol also showed similar activity. Thermal stability of the organic solvent partition fraction exhibited a 28~44% decrease in the activity, implying that the unstable components to heat is present in the fraction. The treatment of proteinase K to water extract increased 10~20% of DPPH activity, suggesting that peptides, released from total proteins, partially increased the antioxidant activity. Altogether, we suggest that the insect extracts having the anti-oxidative property are very useful resources to develop a functional food.
Keywords: *T. molitor*, peptide, organic solvent extraction, methanol fractionation, partition, antioxidant.
Mechanisms of Leukemic T Cell’s Resistance to Proteasome Inhibitor Bortezomib

Fu-Shin Chueh
Department of Healthcare and Nutrition Biotechnology, Asia University, Taiwan, R.O.C.
E-mail address: fushin@asia.edu.tw

Fu-Yu Chueh
Department of Biomedical Sciences, College of Medicine, Chang Gung University, Taiwan, R.O.C.
E-mail address: fuyu52@gmail.com

Chao-Lan Yu\textsuperscript{b,*}
Department of Biomedical Sciences, College of Medicine, Chang Gung University, Taiwan, R.O.C.
E-mail address: clyu@mail.cgu.edu.tw

1. Background/ Objectives and Goals
Bortezomib, a reversible proteasome inhibitor, has been approved by FDA in treating multiple myeloma and mantle cell lymphoma patients. Numerous clinical trials are ongoing to evaluate the efficacy of bortezomib and its derivatives in treating human cancers. One of the major concerns in using bortezomib is that patients develop resistance during the course of treatment and cancer relapse. The purpose of our study is to define the mechanism of bortezomib resistance in cancer therapy and to identify novel approaches in overcoming the resistance.

2. Methods
To explore the underlying mechanisms, we established a bortezomib-resistant human acute T lymphoblastic cell line Jurkat-BR (48hr IC50>200nM). Apoptosis assay, mitochondrial membrane potential assay, and mitochondrial reactive oxygen species analysis determine the effects of bortezomib on cell death and mitochondrial function. The Jurkat-BR cell line was treated with different protein degradation inhibitors and signal transducer and activator of transcription 5 (STAT5) inhibitors. Cell viability assays were done to define the optimal dosage of the inhibitors. STAT expression was determined by quantitative RT-PCR and Western blot analyses.

3. Expected Results/ Conclusion/ Contribution
Compared with the parental control (Jurkat-P), the established resistant Jurkat clone (Jurkat-BR)
tolerates significantly higher levels of bortezomib. The FDA-approved second-generation irreversible proteasome inhibitor, carfilzomib, can effectively overcome bortezomib resistance. MLN 4924 inhibits the pathway upstream of proteasome and can overcome bortezomib resistance at a later time point. In contrast to STAT3 and STAT5a, STAT5b is significantly elevated at both protein and mRNA levels in Jurkat-BR cells. Both pimozone, a specific inhibitor of STAT5 tyrosine phosphorylation, and STAT5I (CAS# 285968-31-4), an inhibitor targeting STAT5 SH2 domain, synergize with bortezomib in killing Jurkat-BR cells. These results support the importance of STAT5b upregulation in acquiring bortezomib resistance and the clinical benefit of second-generation proteasome inhibitors. They also suggest that pimozone and other STAT5 inhibitors may be beneficial in treating cancer patients who acquire bortezomib resistance through upregulating STAT5.

Keywords: bortezomib resistance, carfilzomib, STAT5, leukemic T cells
ICCBES-1147
Research Tournefortia Sarmentosa Chemical Analysis of the Anti-Prostate Cancer

Chia-Hsin Lin, Yueh-Hsiung Kuo, Chao-Lin Kou*
Department of Pharmaceutical Sciences and Chinese Medicine Resources,
China Medical University
Email: jocelyn0625@hotmail.com

Jing-Gung Chung
Department of Biological Science and technology, China Medical University

Abstract
According to the American Cancer Society report 2015 indicated that approximately 1,658,370 cases of cancer cases are diagnosed, and about 589,430 people died of cancer, accounting for one third of the deaths, which accounted for about prostate cancer in men 4%. Prostate cancer is the most common cancer in American men. In Taiwan, prostate cancer accounts for about 10.4 percent of male cancer mortality, ranked sixth, and there is an increasing trend. To overcome the phenomenon, many scholars now seek to natural and human natural compounds with fewer side effects or ingredients as novel anticancer drugs.

Tournefortia sarmentosa is the common folk medicine in Taiwan. Its stems and leaves can help circulation, expelling wind, detoxification, swelling and other effects. It contains polyphenolic compounds. Polyphenolic compounds which can effectively protect nerve cells, antibacteria, antioxidant and also can help immunomodulatory.

In our study, we wanted to know which one compound is effective on the prostate cancer cell line DU-145, and then what the important compounds are also in T. sarmentosa. We analyzed the chemical compounds by High Performance Liquid Chromatography (HPLC) and Nuclear Magnetic Resonance Spectroscopy (NMR).

Key Words: Tournefortia sarmentosa, prostate cancer, DU-145, chemical analysis
ICCBES-1156

Genistein Combined with L-Asparaginase Induced Human Leukemia HL-60 Cell Apoptosis

Yin-Chen, Hsiao
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: god_loves_crazy@yahoo.com.tw

Jing-Gung, Chung*
Department of Biological Science and Technology, China Medical University, Taiwan
Email address: jgchung@mail.cmu.edu.tw

1. Background/Objective and Goals
Chemotherapy is the one way therapy for the AML patients; however there are lots of side effects after treatment. L-asparaginase (Asp) is an ALL patients first line drug has been used in many years and also approved by FDA. Genistein (Gen) is an isoflavones isolated from soybeans already proved anticancer in different cancers. Our aim was to find a natural compound synergized with clinical drug to become a new strategy to cure patients with leukemia.

2. Methods
To evaluate the synergistic activity after combination of Asp and Gen, cell apoptosis were determined by flow cytometry with PI or Annexin V staining. After drugs treatment the cell mitochondrial membrane potential (MMP) levels and calcium ion release were detected by flow cytometer with DiOC₆ or Fluo-3AM staining. The apoptosis-related proteins and autophagy-related proteins were measured by Western blotting.

3. Results/Conclusion/Contribution
After treatment of two drugs in different human leukemia cancer cells (K562, THP-1, HL60, U937), HL60 cells were more sensitivity than other cells. The results also showed that Asp combined with Gen expose to HL60 cells enhanced cell apoptosis more affected than mono-drug treatment through many different pathways such as caspase-dependent and mitochondria pathways and decreased autophagy formation in vitro.

Keywords: AML, Synergistic, L-asparaginase, Genistein, Apoptosis
ICCBES-1159
CantharidinInduces Apoptosis and Autophagy in U2-OS Human Osteosarcoma Cells

Chia-Ching, Chen\textsuperscript{a,*}, Jing-Gung, Chung\textsuperscript{b,#}

\textsuperscript{a} Department of Biological Science and Technology, China Medical University, Taichung 404, Taiwan
E-mail address: t181182@gmail.com

\textsuperscript{b} Department of Biological Science and Technology, China Medical University, Taichung 404, Taiwan
E-mail address: jgchung@mail.cmu.edu.tw

10. Background/ Objectives and Goals
Cantharidin (CTD) is the chief compound secreted by Blister beetles which has been long-term used as Chinese traditional medicine which have evidenced with anti-cancer effects in various human cancers. However, the mechanism of CTD-induced cell death in U2-OS osteosarcoma cells is not well known.

11. Methods
U2-OS cells were treated with various concentrations of CTD and examined the effects of cell viability, cell cycle and apoptosis, along with time-dependent treatment to evaluate the reactive oxygen species (ROS) production, mitochondrial membrane potential ($\Delta \Psi m$) and intracellular Ca$^{2+}$ levels by using flow cytometer. With acridine orange (AO) and monodansyl cadaverine (MDC) staining defined the induction of autophagy in time-dependent manner. The apoptosis and autophagy related protein were thus detected by Western blotting.

12. Expected Results/ Conclusion/ Contribution
Began with effects of CTD on U2-OS cells; the cell viability was decreased in dose-dependent manner, further the induction of apoptosis increasing. To determine the cell DNA damage response and resulting in cell cycle arrest with apoptosis-triggering phenomenon, we then examined the DNA condensation and cell cycle. Our data showed that CTD treatment induced G2/M phase arrest and the percentage of sub-G1 (apoptosis) development. In DAPI experiment, it was obvious DNA condensation observed after CTD treated. In addition, we defined the mechanism of CTD-inducing apoptosis, likewise detecting intercellular of ROS production, MMP and Ca$^{2+}$ levels. Together with these results indicated that both ROS versus Ca$^{2+}$ levels were increased, but MMP rather increased than decreased. We also discussed the autophagy in U2-OS cells by AO and MDC staining. These data suggested a strong effect of autophagy with CTD treatment. At last, the level of apoptotic and autophagic proteins changed that we predicted CTD inducing cell death through these signal transduction in U2-OS cells. Based on
those observations, we suggested CTD could be a potential natural anti-cancer candidate.

Keywords: Cantharidin, U2-OS, Apoptosis, Autophagy
ICCBES-1166
Co-Delivery of siRNA and Plasmid Using PEI Polymer Incorporating γ-PGA for Osteosarcoma Cancer Therapy

Shu-Fen Peng*
Department of Biological Science and Technology, China Medical University, Taiwan, R.O.C.
E-mail address: sfpeng@mail.cmu.edu.tw

Wen-Wen Huang
Department of Biological Science and Technology, China Medical University, Taiwan, R.O.C.
E-mail address: wwhuang@mail.cmu.edu.tw

Hung-Kun Hsu
Department of Chemistry, National Tsing Hua University, Taiwan, R.O.C.
E-mail address: d947624@gmail.com

1. Background/ Objectives and Goals

Delivery of siRNA or functional genes has been recognized as a promising approach in cancer therapy. The p53 tumor suppressor can arrest cell cycle and induce apoptosis during cellular stress occurring. MDM2 is an E3 ubiquitin ligase that binds directly to p53 and leads the proteosomal degradation of p53 proteins. Several cancer cells, including U-2 OS osteosarcoma cell, have been demonstrated the overexpression of MDM2 and then resulted in the rapid degradation of p53 proteins.

Polyethylenimine (PEI), a cationic polymer, condenses nucleic acid into highly compacted nanoparticles and shows high transfection efficiency in gene delivery system. Its high transfection efficiency contributes to the cytosolic release of nucleic acids via proton sponge effect. In this study, PEI polymer incorporating anionic gamma-polyglutamic acid (γ-PGA) was used to complex both of MDM2 siRNA and p53 gene. The resulting nanoparticles (PEI/MDM2 siRNA/p53 gene/γ-PGA NPs) were used to silence the MDM2 and expressed high amount of p53 gene to induce cell apoptosis.

2. Methods

PEI/nucleic acids (siRNA and plasmid DNA) with or without γ-PGA at various N/P/C ratios were prepared by an ionic–gelation method. The charge ratio (N/P/C) of test NPs was expressed as the ratio of moles of the amino groups (N) on PEI to the phosphate groups (P) on nucleic acid and the carboxyl groups (C) on γ-PGA. The hydrodynamic sizes and zeta
potentials of test NPs were measured using a Zetasizer. The percentage and fluorescense intensity of cellular uptake were quantitatively assessed by flow cytometry. Cell-cycle analysis of U-2 OS cells treated with optimal ratio of PEI/MDM2 siRNA/p53 gene/γ-PGA NPs was performed by flow cytometry. The expression of apoptosis proteins were investigated by western blotting.

3. Expected Results/ Conclusion/ Contribution

The dual nucleic acid delivery system was developed for osteosarcoma cancer therapy in this study. At first, instead of p53 gene, the peGFP reporter was used for screening the optimal formulations of PEI/nucleic acids. The sizes of PEI/DNA NPs with N/P (charge ratio) ratios ranging from 3/1 to 11/1 were about 100 nm. The GFP expressing percentages of U 2-OS cells transfected with PEI/peGFP NPs were 30-60%. Cells treated with nanoparticles at N/P ratios of 5/1 or 7/1 revealed higher transgene expression than that of 3/1, 9/1, or 11/1. After incorporating γ-PGA in PEI/DNA complexes, a significant increase in their transfection efficiency was found. The cellular uptake results of cells treated with PEI/Alexa-647 siRNA/peGFP gene/γ-PGA NPs showed that high amount of γ-PGA (N/P/C=5/1/2 or 5/1/3) reduced the binding capacity of PEI with siRNA. Cells transfected with PEI/MDM2 siRNA/p53 gene/γ-PGA NPs revealed cell cycle arrest in S phase by flow cytometry analysis. Cells treated with PEI/MDM2 siRNA/p53 gene/γ-PGA NPs exhibited reduced cell viability by MTT assay. Finally, the increased expression of apoptosis-related proteins indicated the anti-tumor activities of PEI/MDM2 siRNA/p53 gene/γ-PGA NPs. The aforementioned results suggest that PEI/dual nucleic acids/γ-PGA NPs can be a potential approach for targeting overexpressed gene in cancer therapy.

Keywords: Polyethylenimine, γ-polyglutamic acid, MDM2 siRNA, p53 gene
ICCBES-1198
Combination with 5-Fluorouracil and Fisetin Promoted Cell Apoptosis in Human Gastric Cancer AGS Cells

Ying-Ru Huang
Department of Biological Science and Technology, China Medical University, Taiwan
brave8947@gmail.com

Shu-Fen Peng
Department of Biological Science and Technology, China Medical University, Taiwan
sfpeng@mail.cmu.edu.tw

Jing-Gung Chung
Department of Biological Science and Technology, China Medical University, Taiwan
jgchung@mail.cmu.edu.tw

1. Background/Objectives and Goals
Globally, gastric cancer is the second leading cause of cancer-related deaths; the incidence rates for gastric cancer are high in Asian countries. Currently, the available treatments for gastric cancer are inadequate. With the recent advanced techniques, the overall give-year survival rate of gastric cancer patients ranges from 10%–30%. However, patients of gastric cancer in severe stages are untreatable. Hence, there is urgency to identify novel therapeutic agents that can reduce the mortality of cancer patients with lower side effects. Natural herbs have gained attraction in the present era by controlling cancer as an alternative therapeutic drug. It has been reported that high uptake of fruit and vegetables, which are rich in fisetin, is associated with low incidence of cancer. Therefore, a new natural source of anticancer compounds with relatively fewer side effects would be a valuable tool in cancer therapy. Among we found experimentally tested combination of 5-FU and fisetin in AGS cells and may increase the anti-cancer effect. Therefore, we will use a combination of two drugs.

2. Methods
Cell viability and some apoptosis-induced factors were measured by flow cytometry. Percentage of apoptotic cells and DNA fragmentation were indicated by DAPI staining and TUNEL assay. Western blot was used for detected protein expression in AGS cells.

3. Expected Results /Conclusion /Contribution
Our research indicated that the cytotoxicity of the drug combination of 5-FU and fisetin were higher than a single drug treatment. By the cell viability assay, fisetin could enhance the anti-tumor effect of 5-FU on AGS cells. According to the results of western blotting analysis,
the promoted apoptosis effect resulted from the combination of 5-FU and fisetin were intrinsic-signal mediated pathway. The downstream protein expressions of intrinsic signal pathway were further tested. Based on those observations, our finding may provide more information and novel therapeutic strategies in the treatment of cancer.

Keywords: Fisetin, 5-FU, drug combination, AGS, apoptosis
ICCBES-1205
Rat’s Growth and Change of Intestinal Microbiota by Supply of Beechwood Creosote

Jae Young Kim, Tae Wan Kim, Sam Woong Kim, Jung Seok Choi, Jeongim Ha, Eun Mi Lee
Swine Science & Technology Center,
Gyeongnam National University of Science & Technology, Korea
prlrkim@gntech.ac.kr

Jeong A Kim, Da Yoon Yu, In Sung Kim, Hong Yeon Hee, Chul Wook Kim, Kwang Keun Cho
Department of Animal Resources Technology, College of Life Science,
Gyeongnam National University of Science & Technology, Korea

1. Background/Objectives and Goals
Beechwood creosote which is to act the agent of anti-bacteria and inhibition of the intestinal fluid secretion has been used anti-diarrheal medicine. The creosote was tested for its effects of growth and change of intestinal microbiota in rats, with the objective to use the creosote as an antibiotic substitute.

2. Methods
Thirty rats (4 weeks old) were divided to 5 groups for 4 weeks; normal, antibiotic fed, and 0.2%, 0.4% and 0.8% creosote fed group. To analyze intestinal microorganisms, the pyrosequencing was performed with 16S ribosomal RNA genes from the intestinal contents.

3. Expected Results /Conclusion
There were no significant differences in growth efficiency among the all groups, but trended to show high feed efficiency in the creosote fed groups. As a result of the intestinal microorganisms, they were distributed 229 species in the normal group, 245 species in antibiotic group, 284 species in the 0.2% creosote group, 276 species in the 0.4% creosote group and 324 species in the 0.8% creosote group. The creosote feeding promoted the higher species diversity in the intestine. Clostridium and Turicibacter genera showed the dose-dependent decrement in creosote groups in comparison with normal and antibiotic groups. Lactobacillus genus was the high distribution in the creosote groups by contrast with the antibiotic group.

In conclusion, the creosote did not influence the growth in the rat, and decreased the pathogenic bacteria in the intestine. We consider that the creosote can be used as an antibiotic substitute.
Keywords: Beechwood creosote, antibiotic, intestinal microbiota
ICCBES-1215
Enhanced Apoptosis Effects by Nanoparticles Composed of Novel Surfactant and PLGA/Curcumin on Non-Small Cell Lung Cancer

Hao-Yi Suen
Departments of Biological Science and Technology, China Medical University, Taiwan
i04304v@gmail.com

Shu-Fen Peng*
Departments of Biological Science and Technology, China Medical University, Taiwan
sfpeng@mail.cmu.edu.tw

Hung-Kun Hsu
Department of Chemistry, National Tsing Hua University, Taiwan
d947624@gmail.com

Chun-Cheng Lin*
Department of Chemistry, National Tsing Hua University, Taiwan
cclin66@mx.nthu.edu.tw

1. Background/ Objective and Goals
Curcumin (Cur) is an ingredient from the rhizomes of Curcuma longa L. It has the function of hypolipidemic effects, anti-inflammatory, anti-oxidation, and anti-tumor. Low solubility, high rate of metabolism, and poor bioavailability are the limitation of curcumin for clinical applications. Poly(lactic-co-glycolic acid) (PLGA) is an FDA approved biomaterial and it’s biocompatibility and biodegradability can solve the disadvantages of curcumin. In this study, a novel surfactant, HP, was synthesized to develop PLGA/Curcumin nanoparticles (PLGA/Cur NPs). The nanoparticles prepared with the HP surfactant has the properties of cell penetration and high drug loading efficiency. We used HP surfactant to prepare PLGA/Cur NPs to enhance the apoptosis effects of curcumin on A549 non-small cell lung cancer cells.

2. Methods
PLGA/Cur NPs were prepare by using the single emulsion method. The size and zeta potential of nanoparticles were measured by Zetasizer. In vitro cytotoxicity of PLGA/Cur NPs was determined by MTT assay. The cellular uptake analysis of PLGA/Cur NPs and cell cycle arrest of A549 cells were detected by flow cytometer.
The formation of apoptotic body was observed by DAPI staining. And the expression of apoptosis protein was investigated by western blotting.

3. Expected Results/ Conclusion/ Contribution

A high loading efficiency and enhanced apoptosis effects of nanoparticles were developed in this study. The loading efficiency of PLGA/Cur NPs almost achieved 100%. The size of PLGA/Cur NPs were approximately 270 nm, and zeta potential of nanoparticles were about 50 mV. By MTT assay, the viability of cells treated with free curcumin or PLGA/Cur NPs was 30 or 40 µm, respectively. Cells treated with free curcumin or PLGA/Cur NPs revealed the G2/M phase arrest. By statistical analyses, the sub G1 population increased twofold in the cells treated with PLGA/Cur NPs compared with the cells treated with free curcumin. By DAPI staining, cells treated with PLGA/Cur NPs exhibited obviously increased apoptotic body formation. Increased apoptosis protein expressions illustrated the anti-tumor activity of PLGA/Cur NPs. The aforementioned results indicated that the nanoparticles developed in this study will provide a potential lung cancer therapy.

Keywords: Curcumin, PLGA, Non-small Cell Lung Cancer, Apoptosis
ICCBES-1222
Effects of Coenzyme Q0 on Non-Alcoholic Steatohepatitis

Yu-Wen Chi
Department of Biological Science and Technology, China Medical University, Taiwan
tw112236@gmail.com

Wen-Wen Huang*
Department of Biological Science and Technology, China Medical University, Taiwan
wwhuang@mail.cmu.edu.tw

Wai-Shan Chung
Department of Surgery, Chang Gung Memorial Hospital, Taiwan
u9601507@cmu.edu.tw

1. Background/ Objectives and Goals
Non-alcoholic fatty liver disease (NAFLD) is divided into simple hepatic steatosis, non-alcoholic steatohepatitis (NASH), fibrosis, cirrhosis and liver cancer. As fatty acid significantly increases in liver, steatosis produces a lot of reactive oxygen species (ROS). Once the antioxidant system is unable to reduce ROS level, the liver might produce peroxidation products to cause liver cell damage and lead to NASH. According to academic papers, antioxidants such as vitamin E can effectively treat NASH. Coenzyme Q family plays an indispensable role in the mitochondrial respiration and is powerful antioxidant group. The aim of this study was to determine the mechanism of Coenzyme Q0 (Co Q0) on HepG2 cellular steatosis induced by free fatty acids (FFAs).

2. Methods
The cells were treated with different concentrations of Co Q0 (10, 15, 20 and 25 μM) for 24 h and cell viability was evaluated by MTT assay. The model of HepG2 cell steatosis was induced by palmitic acid (PA) for 24 h, then lipid toxicity were used MTT assay to detect cell viability and was used Oil Red O staining method to judge the lipid accumulation. Reactive oxygen species level was measured by utilizing flow cytometry via H2DCFDA staining.

3. Expected Results/ Conclusion/ Contribution
Quantities of 15, 20 and 25 μM of Co Q0 were significantly toxic to HepG2 cells. In contrast, 10 μM of Co Q0 showed no substantial decrease in cell viability, which were used for further studies. PA triggered significant cell death in HepG2 cells and we found LC₅₀ was 150 μM at 24-hour treatment. Hep G2 cells which induce PA of 150μM increased intracellular lipid contents dyed pink were visually observed by microscope.
We predict that Co Q0 may decrease ROS level and inhibit the formation of fatty acids in HepG2 cell steatosis. Based on the prediction above, Co Q0 might be a potential therapeutic compound against NASH by suppressed ROS level and decrease formation of FFAs.

Keywords: Non-alcoholic steatohepatitis, Coenzyme Q0, Palmitic acid and Hep G2 cell lines
Identification of a Synonymous SNP in the FTL Gene and its Association with Meat Quality Traits

Tae Wan Kim, Eun Mi Lee, Jung Hye Hwang, Eun-Jung Kim, Seul Gi Kwon, Da Hye Park, Deok Gyeong Kang, Il-Suk Kim, Jae Young Kim, Sam Woong Kim, Jung Seok Choi, Jeongim Ha* and Chul Wook Kim*
Swine Science and Technology Center,
Gyeongnam National University of Science & Technology, South Korea
E-mail: jiha@gntech.ac.kr or cwkim@gntech.ac.kr

1. Background/Objectives and Goals
Meat quality is affected by various factors, including genetics and the environment. Single nucleotide polymorphisms (SNPs) in specific genes are suggested to be predictive for carcass traits and meat quality. Ferritin light chain (FTL) is a subunit of the ferritin protein, which plays an essential role in intracellular iron storage. Our purpose of this study is to evaluate the association of SNPs in FTL gene and meat quality in Berkshire pig.

2. Methods
FTL mRNA levels in different organs of four pig breeds, Berkshire, Duroc, Landrace and Yorkshire were examined by RT-qPCR. Genomic DNA was then isolated from longissimus dorsi muscles from 416 Berkshire pigs. The genotyping of SNPs in the FTL gene and meat quality was analyzed. Next, the association between genotype in FTL gene and meat quality traits was determined using statistical analysis.

3. Expected Results/Conclusion/Contribution
The expression of FTL mRNA in four pig breeds was examined. Compared to other organs, FTL mRNA levels were noticeably higher in the livers of all four breeds. To identify novel SNPs in the FTL gene, the liver tissue of Berkshire pig was examined by RNA-Sequencing and a synonymous SNP, FTL c.472C>G Pro, was identified. In the same population, various meat quality traits were evaluated and the relationship between FTL genotype and meat quality was examined. The identified FTL SNP was significantly associated with carcass weight, meat color, drip loss, water holding capacity, post-mortem pH_{24hr}, post-mortem temperature at 1 h and chemical composition (collagen and fat content). The significant differences in drip loss and water holding capacity may be due to changes in 24hr post-mortem pH. The relationship between gender and meat quality was also analyzed in Berkshire pigs. Together, these data suggest that FTL synonymous SNPs may be an important factor for determining meat quality in Berkshire pigs.
Keywords: FTL, SNP, meat quality, pig
ICEAI-1086
Observation of Skin Inflammation Process with Optical Coherence Tomography

Tsung-Lin Tsai \textsuperscript{a}, Feng-Yu Chang \textsuperscript{a}, Bo-Huei Huang \textsuperscript{a}, Yan-Jyun Hu \textsuperscript{a}, Chun-Chieh Wang \textsuperscript{b, c, d}, Tzu-Hao Hsiung \textsuperscript{a}, and Meng-Tsan Tsai\textsuperscript{1, d, g}

\textsuperscript{a} Department of Electrical Engineering, Chang Gung University, Taiwan
\textsuperscript{b} Departments of Radiation Oncology and Obstetrics and Gynecology, Chang Gung Memorial Hospital, Taiwan
\textsuperscript{c} Department of Medical Imaging and Radiological Science, Chang Gung University, Taiwan
\textsuperscript{d} Medical Imaging Research Center, Institute for Radiological Research, Chang Gung University and Chang Gung Memorial Hospital at Linkou, Taiwan

Email: mttsai@mail.cgu.edu.tw

Inflammation is the complex biological response of vascular tissues to harmful stimulation, including pathogens, damaged cells, or irritants. The protective response due to inflammation involves host cells, blood vessels, and proteins and other mediators that is intended to eliminate the initial cause of cell injury, as well as the necrotic cells and tissues resulting from the original insult, and to initiate the process of repair. In this study, we develop swept-source optical coherence tomography (SS-OCT) system for investigating inflammation process of skin in the mouse model. The used swept-source is centered at 1060 nm with a broadband spectral range of 100 nm, corresponding to an axial resolution of 5 mm. In addition, the scanning rate of laser can achieve 100 kHz, enabling to provide a frame rate of 100 frame/s in our OCT system. Moreover, according to the use objective lens for sample scanning, the transverse resolution of our OCT system is approximately 7 mm. This system can provide 2D or 3D scanning ability. For 3D imaging, the physical imaging area is 2x2x2mm\textsuperscript{3}, consisting of 1000x500x1024 voxels.

In our experiment, 3-week-old B6 mouse model were used for the study on inflammation. Then, a window chamber was sutured on its back for facilitating observing. During the scanning process, the mouse was anesthetized and fixed on a scanning stage for 2D/3D OCT imaging. With OCT scanning, 3D morphological and vascular information during inflammation process, the results showed that the angiogenesis sue to inflammation can be observed. In the future study, such OCT will be implemented for in vivo human skin.
Fig 1. The angiogenesis images obtained at different time points.
ICCBES-1035

Inhibition of X-Ray Repair Cross-Complement Group 1 (XRCC1) Expression by Curcumin Enhances Cisplatin-Induced Cytotoxicity in Human Lung Cancer Cells

Jyh-Cheng Chen
Department of Biochemical Science and Technology, National Chiayi University, Taiwan
E-mail address: jyhcheng@mail.nkyu.edu.tw

Tai-Jing Wang
Department of Biochemical Science and Technology, National Chiayi University, Taiwan
E-mail address: s1030697@mail.nkyu.edu.tw

Hao-Yu Zheng
Department of Biochemical Science and Technology, National Chiayi University, Taiwan
E-mail address: s1023403@mail.nkyu.edu.tw

Wen-Ching Chen
Department of Biochemical Science and Technology, National Chiayi University, Taiwan
E-mail address: s1023405@mail.nkyu.edu.tw

Yun-Wei Lin*
Department of Biochemical Science and Technology, National Chiayi University, Taiwan
E-mail address: linyw@mail.nkyu.edu.tw

Objectives
Cisplatin is a well-studied and widely used chemotherapeutic agent. It is effective in the treatment of several types of human cancer, including the advanced human non-small cell lung cancer (NSCLC). Curcumin (diferuloylmethane) is a yellow pigment derived from the rhizome of Curcuma longa, and has been proved to have antiproliferative and antitumor properties. XRCC1 is an important scaffold protein involved in base excision repair, and plays an important role in the development of lung cancer. However, it is unclear whether curcumin could enhance the sensitivity of cisplatin through modulation of XRCC1 expression in NSCLC.

Materials and Methods
After the cisplatin treatment, the XRCC1 mRNA level was determined by real-time PCR analysis. Protein levels of XRCC1, phospho-MKK3/6, phospho-p38 MAPK were determined by Western blot analysis.
We used specific XRCC1 small interfering RNA or p38 inhibitor to examine the role of
XRCC1 in regulating the cytotoxic effects of cisplatin. Cell viability was assessed by MTS assay, trypan blue exclusion, and colony-forming ability assay.

**Results**

In this study, cisplatin treatment increased XRCC1 mRNA and protein expression through p38 MAPK activation in two NSCLC cells lines. Moreover, SB2023580 (p38 inhibitor) decreased the XRCC1 mRNA and protein stability upon cisplatin treatment. Knockdown of XRCC1 in NSCLC cells by transfection of XRCC1 siRNA or inactivation of p38 MAPK resulted in enhancing cytotoxicity and cell growth inhibition induced by cisplatin. Curcumin inhibited the expression of XRCC1 and enhanced the cisplatin-induced cell death and anti-proliferation effect in NSCLC cells. Furthermore, transfection with constitutive active MKK6 or HA-p38 MAPK vectors could rescue the XRCC1 protein level and also the cell survival suppressed by cisplatin and curcumin combination in NSCLC cells.

**Conclusion**

These findings suggested that down-regulation of XRCC1 expression by curcumin can enhance the chemosensitivity of cisplatin in NSCLC cells.

Keywords: XRCC1; cisplatin; curcumin; p38 MAPK; lung cancer
ICCBES-1058
The Mechanisms of Nicotine-Induced Chemoresistance through Stat3 Mediated Autophagy and Glycolysis in Human Bladder Cancer Cells

Rong-Jane Chen
Department of Environmental and Occupational Health, College of Medicine, National Cheng Kung University, Taiwan
E-mail address: janekhc@gmail.com

Ying-Jan Wang, b,c
Department of Environmental and Occupational Health, College of Medicine, National Cheng Kung University, Taiwan
  b Department of Biomedical Informatics, Asia University, Taiwan
  c Department of Medical Research, China Medical University Hospital, China Medical University, Taiwan
E-mail address: yjwang@mail.ncku.edu.tw

1. Background/ Objectives and Goals
Previous studies have demonstrated that bladder cancer patients who are active smokers had poor outcome and treatment efficacy compared to nonsmokers. We have been reported that nicotine, the major addictive constituent in the cigarette, exerts a protective factor against drug induced cytotoxicity and maintained chemoresistance in bladder cancer cells through Stat3-mediated apoptosis inhibition pathways. Stat3 was reported involved in the regulation of autophagy and glycolysis through HIF-1α induction. In addition, recent studies indicated that inhibition autophagy and glycolysis confers chemoresistance that could be an effective strategy for cancer therapy. Therefore, the objective of this study is to investigate whether nicotine-induced chemoresistance could be a consequence of autophagy induction and glycolysis regulated by Stat3 mediated signaling pathways.

2. Methods
T24 bladder cancer cells and nicotine-treatment T24-Nic cells were applied in the study. T24-Nic cells were reported resistant to chemotherapeutic agents in our previous studies. The autophagy induction in T24-Nic cells compared with T24 cells after taxol treatment was analyzed by acridine orange staining detected by flow cytometry, LC3-II induction and p62 expression detected by Western blot analysis, and immunofluorescence staining with LC3II and LAMP-1. Glycolysis and ATP production was determined by Seahorse XF Cell Mito Stress Test Kit. To investigate the role of Stat3 induced autophagy and glycolysis in nicotine-induced chemoresistance, Stat3 was knockeddown by transfected with Stat3 shRNA in T24-Nic cells and the relative signaling pathways were analyzed by flow cytometry and Western blot analysis.
3. Expected Results/ Conclusion/ Contribution

The present results indicated that T24 cells treated with nicotine for 80 passages (T24-Nic cells) increased cell proliferation. Moreover, nicotine treatment induced significantly chemoresistance in T24-Nic cells through inhibition of apoptosis and induction of autophagy. The glycolysis and ATP production was also increased in T24-Nic cells compared with T24 cells after taxol treatment. Western blot analysis indicated that Stat3 up-regulation in T24-Nic cells increased glycolysis and autophagy. Inhibited Stat3 expression significantly reduced autophagy and glycolysis, therefore, enhanced chemosensitivity of T24-Nic cells to taxol. The results indicated the role of nicotine-induced chemoresistance through Stat3-mediated autophagy and glycolysis. Through these models, we can understand the important role of Stat3 in nicotine-induced autophagy, glycolysis and chemoresistance, and further provide the strategy for reducing chemoresistance in cancer therapy.

Keywords: nicotine, chemoresistance, glycolysis, autophagy, bladder cancer cells
ICCBES-1076
The CHAC1-Inhibited NOTCH3 Pathway Involves in Temozolomide-Induced Glioma Cytotoxicity

Peng-Hsu Chen
Graduate Institute of Medical Sciences, College of Medicine, Taipei Medical University, Taiwan

Kuo-Hao Ho
Department of Clinical Pharmacy, School of Pharmacy, Taipei Medical University, Taiwan

Ku-Chung Chen \textsuperscript{b, *}
Graduate Institute of Medical Sciences, College of Medicine, Taipei Medical University, Taiwan
\textsuperscript{b} Department of Biochemistry and Molecular Cell Biology, School of Medicine, College of Medicine, Taipei Medical University, Taiwan
E-mail address: kuchung@tmu.edu.tw

Background
Glioblastoma multiforme (GBM), belonging to high-grade glioma, is the most common and serious primary glioma in adults. Temozolomide (TMZ), an alkylating agent of the imidazotetrazine series, is the first line chemotherapeutic drug in the clinical GBM therapy. However, the course of TMZ therapy will last a lifetime which may cause a financial burden. The drug resistance of TMZ could also decrease the therapeutic effects on the patients. Therefore, to further identify the detail molecular mechanisms of TMZ-mediated cytotoxicity may enhance the efficacy and application of TMZ in clinical therapy of GBM. This study comprehensively analyzed the TMZ-regulated gene networks in GBM cytotoxicity.

Methods and Results
First, we identified TMZ-mediated gene profile and network in U87-MG cells by microarray and ingenuity pathway analysis. We also found that CHAC1 (Glutathione-Specific Gamma-Glutamylcyclotransferase 1) is the most upregulated gene involved in TMZ cytotoxicity. TMZ could increase CHAC1 mRNA and protein levels in a dose-dependent manner. Overexpression and knockdown of CHAC1 expression significantly influenced TMZ-mediated cell viability, apoptosis, caspase3 activation and PARP degradation. By U0126 and shRNA treatment, we found that JNK1/c-JUN pathway participated in TMZ-upregulated CHAC1 expressions. By promoter assay and ChIP analysis, we identified the c-JUN could bind to CHAC1 gene promoter upon TMZ treatment. Furthermore, we found that CHAC1 levels were significantly decreased in glioma cells and GBM patients respectively compared with
astrocyte and normal brain tissues. Overexpression of CHAC1 could enhance apoptotic death in glioma cells via Caspase3/9 activation, PARP degradation, autophagy formation, ROS generation, intracellular calcium increase, and mitochondria membrane potential loss. Finally, from microarray data, we also identified that TMZ could significantly reduce Notch3 mRNA and protein levels which is upregulated in glioma cells and GBM patients. TMZ could also induce CHAC1 to bind to Notch3 protein and inhibit Notch3 active form formation, resulting in attenuating Notch3-mediated downstream signaling pathways.

**Conclusions**

These results emphasize that CHAC1-inhibiting Notch3 signaling plays a critical role in TMZ-mediated cytotoxicity. To clearly clarify the TMZ-mediated CHAC1 function and mechanism may provide novel therapeutic strategies for future glioblastoma therapy and drug development.

Keywords: Temozolomide (TMZ), CHAC1, Notch3, glioblastoma
Electricity Consumption Analysis Using a State-Based Data Mining Approach

I-Chin Wu*, Tzu-Li Chen, Guan-Qun Hong
Department of Information Management, Fu-Jen Catholic University, Taiwan
E-mail address: icwu.fju@gmail.com

Tzu-Chi Liu, Yen-Ming Chen
Industrial Technology Research Institute, Taiwan
E-mail address: chentzuli@gmail.com

1. Background/ Objectives and Goals
Owing to the problems of gradual oil depletion and global warming, energy consumption is a critical issue for energy-intensive industries (e.g., semiconductor, manufacturing, iron and steel, and aluminum). Accordingly, how to reduce energy consumption for sustainability and how to track and manage energy efficiently have become critical and challenging issues. From the perspective of load profiling, several energy-saving techniques have been proposed, including a chart of the variation in the electrical load over a specified period (e.g., yearly, monthly, weekly, and daily) for tracking energy consumption. From another angle, several related studies of load profiles have sought to classify customers based on their energy consumption behaviors in various countries (e.g., Belgium, Taiwan, the U.K., and Brazil). To the best of our knowledge, there are few studies that extract energy consumption patterns from load profiles in order to build a pattern reference database to detect the machine operational states in real-time. In this study, we aim to build an effective electronic energy monitor and analysis framework based on load profiles through streaming data mining and machine learning techniques.

2. Methods
For the proposed study, we collect energy consumption data and the corresponding production and manufacturing domain information from the plans of cooperating iron and steel manufactures. Accordingly, we propose a context-aware, domain-driven energy consumption data mining framework. The kernels of the framework form a prediction model for identifying typical load profiles of each machine and a time-series data mining engine for analyzing and extracting the typical patterns based on the load profiles. The typical patterns will be stored in the reference database for detecting on-line machine operation states. We adopted multilayer perceptions (i.e., a feedforward artificial neural network model), radial basis function and support vector machine models to build prediction models for identifying the normal and abnormal operational states of machines. We used root mean square error (RMSE) to select the best models. Afterward, we refined the time-series data mining method to extract typical
electronic patterns of machines that operated smoothly. That is, the typical patterns of electronic consumption are identified based on a time-series data mining algorithm, i.e., symbolic aggregate approximation (SAX, for short) algorithm. One of the critical assumptions of the SAX algorithm is that it is based on the assumptions of normal distribution of data. However, the variation in electronic data of machines is quite large, and data is also dependent on the machines and their associated operational states. Thus, we will modify and enhance the algorithm to incorporate the machine states information into the algorithm.

3. Expected Results/ Conclusion/ Contribution
In this research, we collect energy consumption data and the corresponding product information of two annealing furnaces during the period from April 1, 2014, to December 31, 2014. We have preliminarily deployed the data warehouse framework to observe and analyze the relationships among various attributes, e.g., electronic power, temperature, weight of product, and so on. Then, we select and confirm the key attributes based on results of analysis and consult with the domain experts. We then conduct a series of experiments to build a prediction model to identify normal and abnormal machines and their operational states for the target annealing furnace. Notably, we discretize the streaming data into n segment with timestamp to build the prediction model. Based on our preliminary analytical results, we have confirmed that either the electronic power or temperature information of the operating machine can help identify the entire machine operational process which is 1440 minutes on average. Then, we use the temperature information of the operating machine to identify three states: warming-up, heat-retaining, and cooling. As mentioned in the method section, we refine the SAX algorithm which is a symbolic representation for time series for dimensionality reduction and indexing with a lower-bounding distance measure to further subsequence patterns extraction. It can help the system detect abnormal energy patterns and machine operational states via energy load profiles to make further energy optimization decisions in real time. In our ongoing work, we conduct experiments to evaluate the effectiveness of the proposed states-based SAX algorithm compared to the classical SAX algorithm. The optimal goal of this series of studies is to deploy a visualized decision support system and then propose actionable energy-saving strategies for the cooperating iron and steel plants to solve real-world problems.

Keywords: Energy consumption analysis, Load profiling, Prediction model, Time-series data mining
ICEAI-1036
Extension of Trace-Driven Simulator for Multi-Core Processors
Hyo-Joong Suh︱The Catholic University of Korea

ICEAI-1055
Fall Detection Based on Thermal Imager
Ying-Nong Chen︱National Central University
Chi-Hung Chuang︱Fo Guang University
Luo-Wei Tsai︱Industrial Technology Research Institute
Kuo-Chin Fa︱National Central University

ICEAI-1067
An Efficient Method for Computing Approximate Top-k Dominating Queries in a Data Stream Environment
Guanling Lee︱National Dong Hwa University
Dong Jhe Jiang︱National Dong Hwa University

ICEAI-1071
An Application of Data Mining to Pain Medicine
Yuh-Jyh Hu︱National Chiao Tung University
Tien-Hsiung Ku︱Changhua Christian Hospital
Yu-Hung Yang︱National Chiao Tung University
Jia-Ying Shen︱National Chiao Tung University

ICEAI-1081
The Selecting Algorithm of Monitoring CCTV Camera in Smart Care Surveillance System
Kiyong Kim︱Kyonggi University
Eunsung Park︱Kyonggi University
Dongsu Seong︱Kyonggi University
Keonbae Lee︱Kyonggi University
ICEAI-1090
Secure Localization with Improved Centroid Method over Wireless Sensor Networks
Shao-I Chu | National Kaohsiung University of Applied Sciences
Yao-Chuan Hsu | National Kaohsiung University of Applied Sciences
Shih-Hao Wang | National Kaohsiung University of Applied Sciences
Chih-Yuan Lien | National Kaohsiung University of Applied Sciences
Yao-Yu Jhuang | National Kaohsiung University of Applied Sciences

ICEAI-1104
A Design of IT2-Based Granular Classifier from Numerical Data with Degree Information of Class Membership
Myung-Won Lee | Chosun university
Keun-Chang Kwak | Chosun university

ICEAI-1115
Automatic Exudate Classification in Diabetic Retinopathy Images Using Neural Network
Ratikanlaya Tanthuwapathom | Mahidol University
Narit Hnoohom | Mahidol University

ICEAI-1166
Two-Stage Haze Removal Algorithm with Color Preserving
Chi-Wei Wang | National Taiwan University
Jian-Jiun Ding | National Taiwan University
Hung-Yi Chen | National Taiwan University

ICEAI-1184
Real Time Sensing and Shadow Robustness Video Foreground Segmentation Algorithm
Yu-Chen Liu | National Taiwan University
Jian-Jiun Ding | National Taiwan University
Yao-Ren Chang | National Taiwan University
Hung-Yi Chen | National Taiwan University

ICEAI-1016
A Spring-Damping Transformation Method for Solving Cauchy Problems of Nonlinear Parabolic Equations without Initial Data
Chih-Wen Chang | Feng Chia University
Shengwen Wang | National Center for High-Performance Computing
ICEAI-1036
Extension of Trace-Driven Simulator for Multi-Core Processors

Hyo-Joong Suh
School of Computer Science and Information Engineering,
The Catholic University of Korea, Korea
hjsuh@catholic.ac.kr

1. Multi-Core / Multiprocessor Simulators

There are various simulators according to the simulation level of the target processors. Gate-level and RTL-level microscopic simulations are most accurate solution in this area of research, but simulation time is become huge in proportional to the details of the target simulation. Thus the common targets of the gate/RTL-level simulations are design validation and bug-fix rather than the performance projection of cache-memory hierarchy. For the macroscopic performance projection of a processor, trace-driven and execution-driven simulations are sufficient enough to be of practical use. SimpleScalar is one of the successful execution-driven simulators that imports an executable file and generates memory cycles to the user programmable back-end parts. But SimpleScalar does not have multiprocessor features, thus a multiprocessor extension was introduced [1]. Mint and Augmint are execution-driven simulators that have native support for multiprocessors. These execution-driven simulators have merit of run-time execution, but some demerit in terms of simulation performance. Trace-driven simulators are another approach which tracks memory traces from the access history of memory references of the applications. But the trace-driven simulators have another limitation by its native property; unique and static sequence of memory reference. It is hard to imitate the property of multiprocessor system because the global sequence of memory accesses is dynamically generated, and conditional branch of each processor can be dependent by dynamic synchronizations. But I focused a multi-core processor in modern handheld devices has less dependency between each cores, thus I extend a trace-driven simulator by hierarchical structure which simply imitates the dynamic property between cores in the processor. By the proposed method, multitasking on multi-core processor can be imitated with the dynamic access sequence using trace-driven simulation.

2. Dinero IV Trace-Driven Simulator and Multi-Core Extension

Dinero IV is simple but powerful trace-driven simulator that can evaluate single core processor [2]. This simulator does not focused on timing and functional correctness, its concentration is memory and cache hierarchy for evaluation of memory properties. It is very useful simulator for early-stage architectural consideration and evaluation of memory and cache hierarchy, but it has limitation that cannot simulate multi core/processor. It is very critical issue on usefulness of simulator because at almost the latest processors have multi-core structure, and some of them
have shared cache on their memory hierarchy. Another issue is the dynamic property of the multi-core processors. Input data of a trace-driven simulator is just memory trace. Thus if memory trace was captured at the point of memory device, dynamic property of multi-core cannot be regenerated when a memory trace was generated. This is focused issue of my extension of Dinero IV simulator. At first, I captured the memory traces of each core of a multi-core processor with benchmark workload, and thus I got several traces from each cores. These traces are integrated with hierarchical simulation structure as shown in Fig. 1

![Hierarchical Simulation Flow](image)

**Fig. 1 Simulation flow of hierarchical caches**

By using hierarchical layer of simulator modules and trace control/address handling modules, proposed hierarchical simulation system can handle dynamic property of multi-core or processors system even though it originated from trace-driven simulation.

Keywords: Trace-driven simulation, Multi-core, Dynamic property, Hierarchical caches

**Acknowledgement**

This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2013R1A1A2057967)

**References**


ICEAI-1055

Fall Detection Based on Thermal Imager

Ying-Nong Chen*, Kuo-Chin Fan
Dept. of Computer Science and Information Engineering, National Central University, Taiwan
E-mail address: yingnnong1218@gmail.com

Chi-Hung Chuang
Dept. of Applied Informatics, Fo Guang University, Taiwan
E-mail address: chchuang@mail.fgu.edu.tw

Abstract
Accidental fall is the most prominent factor that causes the accidental death of elder people due to their slow body reaction. Automatic fall detection is then an emerging technology which can assist traditional human monitoring and avoid the drawbacks suffering in health care systems especially in dusky environments. In this paper, a novel fall detection system based on coarse-to-fine strategy is proposed focusing mainly on dusky environments. Since the silhouette images of human bodies extracted from conventional CCD cameras in dusky environments are usually imperfect due to the abrupt change of illumination, our work adopts thermal imager instead to detect human bodies. In our approach, the downward optical flow features are firstly extracted from the thermal images to identify fall-like actions in the coarse stage. The horizontal projected motion history images (MHI) features of fall-like actions are then designed to verify the fall by the support vector machine (SVM) in the fine stage. Experimental results demonstrate that the proposed method can distinguish the fall incidents with high accuracy even in dusky environments and overlapping situations.

Keywords: Fall detection, optical flow, motion history image

1. Background/ Objectives and Goals
Accidental fall is the most prominent factor that causes the accidental death of elder people due to their slow body reaction. Fall accidents usually occur at night with nobody except the elder people if they live alone. It is usually too late to remedy the tragedy when the body is discovered hours or days after with the occurrence of accidental fall. In the occurrence of fall incident, humans usually lie flat on the ground. However, we cannot merely use the images to perceive whether this person is lying on the ground. Hence, we have to detect and avoid the risk caused by fall action before the existence of really lying on the ground. According to the survey, a sudden fainting or body imbalance is the main reason to cause a fall. No matter what kind of reasons, fall is a warning that the subject may be in danger.
Moreover, if the incidents occur in a dusky and unattended environment, people usually miss the prime time for rescue because the silhouette images of human bodies extracted from conventional CCD cameras in dusky environments are usually invisible or imperfect due to the illumination constraint. To remedy this problem, a fall detection system using a thermal imager (see Fig. 1) to capture the images of human bodies is proposed in this paper. By using the thermal imager, the human bodies can be accurately located even in a dusky environment. For comparison, Fig. 2 (a) shows the images obtained by a CCD camera in a dusky environment, whereas Fig. 2 (b) shows the images obtained by a thermal imager in the same environment. It is obvious that the thermal imagers can extract more clear and intact human bodies in the dusky environments than CCD cameras.

Fig. 1: The thermal imager.
Moylan illustrated the gravity of falls as a health risk with abundant statistics. Larson described the importance of falls in elderly. National Center for Health Statistics showed that more than one-third of ages 65 or older fall each year. Moreover, 60% of lethal falls occur at home, 30% occur in public region, and 10% happen in health care institutions for ages 65 or older. In the literatures of fall detection, Tao et al. applied the aspect ratio of the foreground object to detect fall incidents. Their system firstly tracks the foreground objects and then analyzes the sequences of features for fall incidents detection. Anderson et al. also applied the aspect ratio of the silhouette to detect fall incidents. The rationale based mainly on the fact that the aspect ratio of the silhouette is usually very large when the fall incidents occur. On the contrary, the aspect ratio is much smaller when the fall incidents do not occur. Juang proposed a neural fuzzy network method to classify the human body postures, such as standing, bending, sitting and lying down. Foroughi et al. proposed a fall detection method using an approximated eclipse of human body silhouette and head pose as features for multi-class support vector machine (SVM). Rougier et al. applied the motion history image (MHI) and variations of human body shape to detect falls. Foroughi et al. proposed a modified MHI integrating the time motion image (ITMI) as the motion feature. Then, the eigenspace technique was used for motion feature reduction and fed into individual neural network for each activity. Liu et al. proposed a nearest neighbor classification method to classify the ratio of human body silhouette of fall incidents.
In order to differentiate between the fall and lying, the time difference between fall and lying was used as a key feature. Liao et al. proposed a slip and fall detection system based on Bayesian Belief Network (BBN). They used the integrated spatiotemporal energy (ISTE) map to obtain the motion measure. Then, the BBN model of the causality of the slip and fall was constructed for fall prevention. Olivieri et al. proposed a spatiotemporal motion feature to represent activities termed motion vector flow instance (MVFI) templates. Then, a canonical eigenspace technique was used for MVFI template reduction and template matching.

In this paper, a novel fall detection mechanism based on coarse-to-fine strategy which is workable in both day and dusky environments is proposed. In the coarse stage, the downward optical flow features are extracted from the thermal images to identify fall-like actions. Then, the horizontal projected motion history images (MHI) features of fall-like actions are used in the fine stage to verify the fall by the nearest neighbor feature line embedding.

The main contributions of this work are three folds. (1) Using the thermal imager instead of CCD camera to capture intact human body silhouettes. (2) Proposing a coarse-to-fine strategy to detect fall incidents. (3) Proposing a scheme to detect fall incidents even though overlapping occurs.

The rest of this paper is organized as follows. In section 2, the proposed fall detection method is presented. In section 3, experimental results are illustrated to demonstrate the soundness and effectiveness of the proposed fall detection method. Finally, conclusions are given.

2. The Proposed Coarse-To-Fine Method

The proposed fall detection mechanism consists of two modules including human body extraction and fall detection. In human body extraction module, temperature frames obtained from the thermal imager are processed with image processing techniques to obtain intact human body contours and silhouettes. In fall detection module, a coarse-to-fine strategy is devised to verify fall incidents. In the coarse stage, the downward optical flow features are extracted from the temperature images to identify possible fall down actions. Then, the 50-dimensional temporal based motion history images (MHI) feature vector is projected into the SVM classifier in the fine stage. Fig. 3 depicts the proposed system flow diagram. The details associated with each step including the human body extraction, the analysis of optical flows in the coarse stage, and the extraction of MHIs in the fine stage are described in the following contexts.
2.1 Human Body Extraction

To improve fall detection accuracy, complete silhouettes of human body must be extracted to obtain accurate bounding box of human body. To this end, the temperature images captured from a thermal imager are binarized by Otsu’s method firstly. Then, the morphological closing operation is employed to obtain a complete human silhouette. Finally, a labeling process is performed to locate each human body in the image and filter out background noises. The process of human body extraction is depicted in Fig. 4. Fig. 4 (a) shows the temperature images captured from the thermal imager, Fig. 4 (b) shows the Otsu’s binarization results, and Fig. 4 (c) shows the results of morphological closing operation. The bounding box of the human silhouette can be successfully generated after the morphological closing operations.
2.2 Optical Flow in the Coarse Stage

After the bounding box of human body has been determined, a coarse-to-fine strategy is utilized to verify fall incidents. The purpose of the coarse stage is to identify possible fall actions. Wu had shown that a fall could be described by the increase in horizontal and vertical velocities. Moreover, this work observes that the histogram of vertical optical flows has also demonstrated the significant difference between walking and falling (see Fig. 5). In our work, a multi-frame optical flow method proposed by Wang is adopted to extract the downward optical flow features inside the extracted bounding box (see Fig. 6) in this stage. A possible fall action can be identified by two heuristic rules:

1) Rule 1: Given 20 consecutive frames, the average vertical optical flows exhibit downward more than 75% of frames.

2) Rule 2: The sum of the average vertical optical flows in 20 consecutive frames is larger than a threshold, say 10 in this study.

As shown in Fig. 6(a), a fall incident may not be identified if the subject is overlapped by the other. To solve this problem, the bounding box is divided into two equal boxes if overlapping occurs. The width of the silhouette is used to identify whether the overlapping occurs or not. The optical flow features are then extracted in each divided box. The one which has larger average downward optical flow is used to identify possible fall action. As a result, the fall incidents can be extracted correctly as shown in Fig. 6(b), and Fig. 6(a) demonstrates the result without using the bounding box division strategy.
2.3 Motion history image in the fine stage

In the coarse stage, most non-fall actions can be filtered out via the downward optical flow features. However, some fall-like actions are identified as fall incidents due to the swing of arms. To solve this problem, we devise a feature vector which is formed by projecting the MHI horizontally to verify fall incidents in the fine stage. MHI proposed by Bobick [18] is a template which condenses a determined number of silhouette sequences into a gray scale image (as Fig. 9(a)) which is capable of preserving dominant motion information. Since the main difference between fall and other actions is the vertical component changes, our work projects the MHI horizontally to obtain a 50 dimensional feature vector using equation (7):

\[
Q(i) = \frac{1}{U_w} \sum_{j=1}^{50} g \left( \left\lfloor \frac{U_h}{50} \times i \right\rfloor, j \right), \quad i = 1, 2, \ldots, 50
\]  

(7)

where \( U_h, U_w, \) and \( g(i,j) \), are the height, the width, and the pixel value of the motion energy in row \( i \) and column \( j \) respectively. \( Q(i) \) is the obtained 50 dimensional feature vector.

Fig. 9(c) and Fig. 9(f) illustrate the comparison between the feature vector of walk and fall in this study. The distributions of the walk action and the fall action are significantly different. As can be seen, the vertical motion information of the fall action is encoded directly with the horizontal projections, which can be viewed as extracting from MHI but not the silhouette. Therefore, the MHI features of fall-like actions will be fed into the SVM verifier to identify fall
incidents after the coarse stage.

Fig. 6: Fall incident in overlapping situation. The first row is the silhouettes, the second row is the corresponding optical flow results, and the third row is the histograms of vertical optical flows. (a) The results generated by original method, (b) the results generated by using dividing method.

3. Experimental results

In this section, experimental results conducted on fall incident detection are illustrated to demonstrate the effectiveness of the proposed method. In this paper, we compare the proposed method with two state-of-the-art methods. The results are evaluated by using the simulated video data set captured from outdoor scenes. The total number of the video data set is 320. In each video, the environment is in the dusky environments as shown in Fig. 2. Only the thermal imager can effectively capture the human silhouette under the environments. Table 1 tabulates the data sets used in the experiments. In this study, videos used for training are different from that used for testing. More specifically, training videos and testing videos were captured under different conditions (different places at different time). Among these data sets, video sequences which contain only one subject are utilized to compare the performance of the proposed
method with other state-of-art fall detection methods and the results will be illustrated in Section 3.1. The identification capability of coarse-to-fine verifier is evaluated and illustrated in Section 3.2. In Section 3.3, the performance of the proposed method is evaluated by using video sequences which contain multiple subjects. Different from the other researches, the experimental results in Section 3.3 demonstrate that the proposed method can effectively detect fall incidents even when multiple persons overlap each other.

3.1. Performance Comparisons of Various Fall Detection Algorithms
The data sets used in this subsection contains only one subject in each video sequence. Two state-of-the-art methods, BBN [11] and CPL [12], are implemented for comparison. The CPL takes a sequence as a sample, whereas the BBN and our proposed method take a frame as a sample. Therefore, the performance comparison of these three methods is based on each video sequence. In the experiments, 60 video sequences of one person are used as training sets and 100 video sequences of one person are used for testing. In our work, the dimensionality of feature vectors is reduced by the PCA transformation to remove noises. More than 99% of the feature information is kept in the PCA process. After the PCA transformation, the SVM model in the fine stage are obtained from the training samples. The performance comparisons of these three methods are tabulated in Table 2. From Table 2, we can notice that the proposed coarse-to-fine strategy of fall detection outperforms the other two methods. It implies that the proposed method is much more effective than the other two methods.

<table>
<thead>
<tr>
<th>Actions</th>
<th>Number of training videos</th>
<th>Number of testing videos</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walk (one person)</td>
<td>30 (5135 frames)</td>
<td>50 (17125 frames)</td>
</tr>
<tr>
<td>Fall (one person)</td>
<td>30 (545 frames)</td>
<td>50 (1822 frames)</td>
</tr>
<tr>
<td>Walk (multiple persons)</td>
<td>30 (5069 frames)</td>
<td>50 (16130 frames)</td>
</tr>
<tr>
<td>Fall (multiple persons)</td>
<td>30 (460 frames)</td>
<td>50 (1810 frames)</td>
</tr>
</tbody>
</table>

3.2 Performance Evaluation of Fall Detection under Overlapping Situations
In this subsection, the performance evaluation of fall detection in overlapping situations is illustrated. Video sequences which contain multiple persons are used for evaluation. Similar to the comparison described in Section 3.1, the SVM classifier is adopted for matching each testing frames in the fine stage. In the experiments, the performance evaluation of fall detection under overlapping situations is conducted based on each video sequence. Here, 30 video sequences are used for training and 100 video sequences are used for testing. The detection results are tabulated in Table 3. The proposed method utilizing coarse-to-fine strategy can effectively detect fall incidents while two persons are overlapping each other and the performance is almost the same as that of the ‘one person fall’ data sets described in Section 3.1.

<table>
<thead>
<tr>
<th>Method</th>
<th>Classification Action (videos)</th>
<th>Reference Action (videos)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ours</td>
<td>Fall</td>
<td>92.00 (46 / 50)</td>
</tr>
<tr>
<td></td>
<td>Walk</td>
<td>4.00 (2 / 50)</td>
</tr>
</tbody>
</table>

4. Conclusions

In this paper, a novel fall detection mechanism based on coarse-to-fine strategy in dusky environment is proposed. The human body in dusky environment can be successfully extracted using the thermal imager and the fragments inside human body silhouette can also be significantly reduced as well. In the coarse stage, the optical flow algorithm is firstly applied on thermal images. Most of walk actions are filtered out by analyzing the downward flow features. In the fine stage, the projected MHI is used as the features followed by a SVM classifier to verify fall incidents. Experimental results demonstrate that the proposed method outperforms the other state-of-the-art methods and can effectively detect fall incidents even when multiple subjects are moving together.

Acknowledgments

The work was supported by Ministry of Science and Technology of Taiwan under Grant nos. MOST104-2221-E-008-030-MY3, MOST103-2221-E-008-058-MY3.

References

An Efficient Method for Computing Approximate Top-k Dominating Queries in a Data Stream Environment

Guanling Lee*
Department of Computer Science and Information Engineering,
National Dong Hwa University, Taiwan, R.O.C
E-mail address: guanling@mail.ndhu.edu.tw

Dong-Jhe Jiang
Department of Computer Science and Information Engineering,
National Dong Hwa University, Taiwan, R.O.C
E-mail address: jhe0518@hotmail.com

Abstract
Because of the development of modern technology, a huge amount of data is produced and changing over time. In a data stream environment, the information is keeping updating; since previous methods which are used in static dataset can neither adopt in stream environment, nor satisfied the needs of users. Therefore, how to find out the data which people are concerned in stream environment becomes an important issue. Top-k dominating query combines the advantages of top-k query and skyline query, not only allow users to control the number of results; but also provide an intuitive scoring function based on dominating score. Therefore, users do not need to design scoring functions themselves.

In this paper, we discuss the problem of finding top-k dominating query in a data stream environment and propose an efficient approximate algorithm, named EAA, for finding the satisfied data with high accuracy. The experimental results show that EAA can answer the result of top-k dominating query faster than previous approaches, and achieve a high accuracy.

Keywords: Top-k dominating query, Data stream, Top-k query, Skyline query

1. Introduction
In recent years, more and more researches and applications focus on multicriteria query processing, that is, the results must satisfy some additional properties or maximize the benefit of the user need. As discuss in [6], the top-k query and skyline query are two widely used multicriteria queries. In top-k query, a scoring function is required to map the data point to a value, and it retrieves the top k data points with respect to the value. The advantage of top-k query is that the number retrieved data point is controlled by the parameter k. However, the scoring function is usually defined by user, and in most cases it is not so intuitive to define an appropriate scoring function.
Skyline query is another solution to cope with multicriteria query. Give a set $P$ of multidimensional points, the skyline operator returns the points in $P$ that are not dominated by any other points. A point $p$ is said to dominate $q$ if $p$ is strictly better than $q$ on at least one dimension and no worse than $q$ on every dimensions. The concept of the skyline operator was first introduced in [2], which explores three algorithms: BNL, divide and conquer, and B-tree-based schemes. A variant of BNL named the sort-filter skyline algorithm was proposed in [4], with the resulting order of points simplifying comparisons. In [8], how to maintain skyline in a dynamic environment was presented. Moreover, the problem of how to compute skyline points in a data stream environment was discussed in [5][9][11]. The benefit of skyline query is that it does not require a scoring function. However, the drawback of skyline query is that the number of retrieved data points is unbounded.

Therefore, by combining the advantages of top-$k$ query and skyline query, the concept of top-$k$ dominating query was proposed and discussed in [10]. In top-$k$ dominating query, the score of a data point $p$ is defined as the number of points dominated by $p$, and the data point with the top $k$ highest scores will be retrieved. Several algorithms were proposed [12][13] to compute top-$k$ dominating query efficiently in a static environment. However, the computation environment of real applications usually adopt data stream model, therefore, a continuous query processing algorithm which can refresh the query result rapidly is needed. In [6], several properties and algorithms were proposed to refresh the query results in the data stream environment efficiently. The detail discussion will be given in next section. In this paper, by adopting the properties proposed in [6] and domination relationship, a method called EAA (Event-driven Approximate Algorithm) is proposed to compute approximate top-$k$ dominating query result in a data stream environment efficiently. Moreover, a set of experiment is performed in several syntactic datasets to compare the performance of the methods proposed in [6]. Experimental results show that the proposed EAA method can compute top-$k$ dominating query in a data stream environment efficiently and effectively.

The remainder of the paper is organized as follows: Section 2 discusses the background knowledge of the problem. Section 3 presents the idea of our approach, experimental results are analyzed in Section 4, and conclusions from this work are drawn in Section 5.

2. Preliminaries
In this section, we will present the concept of skyline and the basic idea proposed in [6]. Let $D=\{d_1,\ldots,d_d\}$ be a $d$-dimensional space and $P=\{p_1,\ldots,p_m\}$ be a set of points on $D$. The formal definition of dominance relationship between two data points and the skyline queries are described in definitions 1 and 2, respectively. We use $p_i.d_j$ to denote the $j$th dimensional value of $p_i$. And without loss of generality, we assume a smaller value represents better performance.
Definition 1: A point $p_i$ is said to dominate $p_j$ on $D$ (denoted by $p_i \prec p_j$) iff

$$\forall d \in D, \ p_i.d \leq p_j.d \ and \ \exists d \in D, \ p_i.d < p_j.d.$$ Moreover, $p_j$ is said to be dominated by $p_i$.

Definition 2: A skyline query returns the points in $P$ that are not dominated by any other point.

The efficiency of skyline query processing is highly dependent on the access order of data points. That is, the earlier the skyline point can be identified, the better the performance of the algorithm. Therefore in [7], the concept of $z$-order is used to determine the processing order of the data point. A $z$-order curve maps multi-dimensional data point into a one-dimensional space, named $z$-address. And this is a one to one mapping. A $z$-address is a bit string calculated by interleaving the bits of all the coordinate values of a data point. According to the discussion of [7], $z$-address has monotonic ordering property. That is, if data point is ordered by non-descending $z$-address, then data points are always placed before their dominated points. In other word, a data point $p$ is impossible to dominate the data point $q$ if $q$’s $z$-address is smaller than $p$’s $z$-address.

In [6], sliding window approach [1] is adopted to compute the top $k$ dominating queries in a data stream environment. In the sliding window model, only the $n$ most recent points, called active points, are considered. To avoid ad hoc computing, [6] adopts the event-driven concept for continuous top $k$ dominating query computing. That is, instead of computing the result for every insertion and deletion (while the sliding window update), the query result is recomputed only when some events are triggered. Moreover, a grid-based indexing scheme is used for bookkeeping purposes. In the following, we will briefly introduce the algorithms proposed in [6]. Table 1 lists the frequently used symbols.

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n$</td>
<td>Number of active points (width of sliding window)</td>
</tr>
<tr>
<td>score($p_i$)</td>
<td>The number of point dominated by $p_i$</td>
</tr>
<tr>
<td>TOPK</td>
<td>The set of $k$ points with the best scores</td>
</tr>
<tr>
<td>now</td>
<td>The current time instance</td>
</tr>
<tr>
<td>score$_j$</td>
<td>The $j$th best score value of the top-$k$ points</td>
</tr>
<tr>
<td>exp$_j$</td>
<td>The $j$th min expiration time of points in TOPK</td>
</tr>
</tbody>
</table>

To avoid too many dominating computations, the point which is not in TOPK is considered as an event. An event contains three attributes <$ept, egt, score$> which indicate event processing
time, event generation time and the score of the data point, respectively. When now=p_i.ept, event p_i is triggered which indicates that p_i has a chance to be included in TOPK. At this time point, the score of p_i is actually computed to determine whether p_i is truly included in TOPK. In the proposed algorithm ADA, the following lemma is proposed and used to compute the optimistic bound of p_i.ept. Moreover, to reduce the exact score computing cost, the score of a new coming point p_i is estimated by using the score of its reference point p_r. Reference point p_r should satisfy the following two conditions: (1) p_r dominates p_i and (2) p_r is not in TOPK. To find proper p_r efficiently, grid index is adopted and the cells which fully dominate or partial dominate p_i are traversed according to its z-address. After getting p_r, score(p_i) can be estimated as score(p_r)-1 which is the upper bound of score(p_i).

Lemma 1[6]: Given the rth minimum expiration time of the top-k dominating points, denoted as exp_r (0 ≤ r < k) and the current time instance now, a point p_i cannot be part of TOPK in less than SI(p_i) time instances, where

\[
SI(p_i) = \min \left\{ \left[ \frac{(score_k^{r-1} - score(p_i))}{2} \right] , \ exp_{r+1} - now \right\}
\]

Instead of proposing algorithm ADA which can find the exact top-k dominating points, to reduce the computation cost, [6] also provided an efficient Approximate Minimum Score Algorithm (AMSA). The basic concept of AMSA is that if the score of a point is low, it is expected that it will remain low during its lifetime. Let minscore(c_j) indicate the smallest possible score of all points contained in cell c_j (in the grid index), in the execution, all points belonging to c_j are excluded from event processing if \( score_1 - score_k < score_k - minscore(c_j) \).

3. Proposed Method

As mentioned above, ADA generates event for each active point and verifies the triggered event to determine the exact top-k dominating result. Moreover, to improve the computation efficiency, in [6] an approximate algorithm, called AMSA, is proposed. In AMSA, events are generated only for those active points whose score is higher than a threshold. However, as long as score(p_i) is no smaller than the threshold, an event will be generated for p_i. Therefore, the number of events in AMSA is unbounded which makes the execution time of the algorithm is not stable. In this paper, we propose an Event-driven Approximate Algorithm (EAA) which can find top-k dominating results efficiently and stably with a very high accuracy. In EAA, only the data point p_i which satisfies the following two conditions is generated as an event.

(1) \( p_i \) is not in TOPK
(2) the rank of \( p_i \) is within \( \left\lceil (n-k) \Delta p \right\rceil + k \)

For example, if \( n=105, k=5 \) and \( \Delta p=20\% \), then we only generate events for the twenty data
points with highest scores (excluding top 5). Moreover, those points are called *qualified points*, and the points not belonging to TOPK and qualified points are called *unqualified points*. In the following discussion, we use $Q$ and $UQ$ to indicate the set of qualified and unqualified points, respectively.

In the data stream model, overdue data point $p_x$ is deleted and new data point $p_i$ is inserted. When the sliding window is updated, one of the four following cases is executed.

1. $p_x$ is an unqualified point, and the reference point $p_r$ of $p_i$ is also an unqualified point. There is nothing need to do in this case.

2. $p_x$ is an unqualified point, and the reference point $p_r$ of $p_i$ is a qualified point. In this case, the event corresponding to the qualified point $p_l$ with the smallest score will be eliminated and $Q = Q - \{p_l\} \cup \{p_i\}$. Moreover, a new event is generated for $p_i$.

3. $p_x$ is a qualified point, and the reference point $p_r$ of $p_i$ is a qualified point. In this case, $p_x$ and $p_i$ are eliminated from and inserted into $Q$, respectively.

4. $p_x$ is a qualified point, and the reference point $p_r$ of $p_i$ is an unqualified point. In this case, $p_x$ is eliminated from $Q$ and we need to find a point $p_n$ in $UQ$ and insert it into $Q$ to maintain the number of qualified points. To find proper $p_n$ efficiently, grid index is adopted and the cells which fully dominated or partial dominated by $p_x$ are traversed according to its $z$-address.

In EAA, events are generated for active data points which satisfy the above two conditions. Moreover, to reduce the exact score computing cost, we adopt lemma 1 proposed in [6] to estimate the score of qualified point. The algorithm can be considered as two parts:

1. Initial phase: In the beginning, we compute the score for each point. Identify TOPK and $Q$, and use a priority queue to store data points in $Q$.

2. Sliding window updated phase: Use the method proposed in [6] to verify triggered event. Eliminate overdue point and insert the new coming point according to the four cases discussed above.

Because EAA can control the quantity of events, the performance is quite stable comparing to AMSA.

### 4. Experimental Results

In this section we compare the performance of our approach with those of ADA and AMSA [6] for synthetic datasets. Following the discussion in [3], three optional distributions were considered: correlated, independent, and anticorrelated. The parameters setting are listed in Table 2. We evaluate the computational cost of our approach and compared the results with the other two methods for the same parameter settings. All algorithms were implemented in C and
the experiments were conducted on computer with a 3.07 GHz Intel Core processor and 3 GB of main memory running Windows 7.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Default value</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sliding window size (n)</td>
<td>10k</td>
<td>3k, 5k, 8k, 10k</td>
</tr>
<tr>
<td>Number of dimensions</td>
<td>2</td>
<td>2-7</td>
</tr>
<tr>
<td>(k)</td>
<td>30</td>
<td>10, 30, 50, 80, 100</td>
</tr>
<tr>
<td>(\Delta p)</td>
<td>1%</td>
<td>1%, 4%, 7%</td>
</tr>
</tbody>
</table>

Tables 3(a)–3(c) show the accuracy of EAA and AMSA under different \(k\) for the independent, correlated, and anticorrelated datasets, respectively. The results indicate that the accuracy of EAA is better than that of AMSA in all the cases. Moreover, the accuracy of EAA increases as \(\Delta p\) increases. This is trivial because the number of generated events increases as \(\Delta p\) increases. The accuracy of EAA almost achieves 100\% (at least 99.94\% when \(\Delta p=1\%\) and \(k=100\)) in all the cases. Therefore, in the following experiments, the default value of \(\Delta p\) is set to 1\%.
Table 3: Accuracy of EAA and AMSA

<table>
<thead>
<tr>
<th>k</th>
<th>EAA</th>
<th>AMSA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Δp = 1%</td>
<td>Δp = 4%</td>
</tr>
<tr>
<td>10</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>30</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>50</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>80</td>
<td>99.999%</td>
<td>100%</td>
</tr>
<tr>
<td>100</td>
<td>99.980%</td>
<td>99.980%</td>
</tr>
</tbody>
</table>

(a) Independent dataset

(b) Correlated dataset

(c) Anticorrelated dataset

Figure 1(a)-1(c) show the effects of the number of dimensions, which indicates that the execution times increase as the number of dimensions increase for all approaches. This is because the probability of a point dominating another one decreases significantly as the number of dimensions increases, especially in the anticorrelated dataset. Moreover, the results show that our approach outperformed the others for all three datasets.

The effects of sliding window size are shown in Figure 2. The results indicate that the execution time increases with sliding window size in all of the approaches. However, our approach significantly outperforms the others. The reason is that the quantity of events can be controlled in EAA. As a result, the execution time of EAA is much stable comparing to that of AMSA.
Conclusions

Recently, more and more researches focus on multicriteria query processing, that is, the results must maximize the benefit of the user need. To achieve this goal, the concept of top-\(k\) dominating query is proposed. In this paper, we discuss the problem of computing top-\(k\)

Fig. 1: Effect of number of dimensions (a) independent (b) correlated (c) anticorrelated

Fig. 2: Effect of sliding window size (a) Independent (b) correlated (c) anticorrelated

5. Conclusions
dominating query in a data stream environment. By adopting the event-driven concept, an efficient approximate algorithm, EAA is proposed. In EAA, events are generated only for the qualified points, that is, the quantity of events can be controlled which make the execution time is efficient and stable. The experimental results show that EAA can answer the result of top-k dominating query faster than previous approaches, and achieve a high accuracy.

6. References

An Application of Data Mining to Pain Medicine

Yuh-Jyh Hu \textsuperscript{b,*}
College of Computer Science, National Chiao Tung University, Taiwan
\textsuperscript{b} Institute of Biomedical Engineering, National Chiao Tung University, Taiwan
E-mail address: yhu@cs.nctu.edu.tw

Tien-Hsiung Ku
Department of Anesthesiology, Changhwa Christian Hospital, Taiwan
E-mail address: tienku@gmail.com

Yu-Hung Yang, Jia-Ying Shen
Institute of Biomedical Engineering, National Chiao Tung University, Taiwan
E-mail address: daniel0318pisces@gmail.com

Jia-Ying Shen
Institute of Biomedical Engineering, National Chiao Tung University, Taiwan
E-mail address: ingrid25109@hotmail.com

Abstract
Several factors affect individual variability in postoperative pain, and they lead to different postoperative analgesic consumption. Many statistical studies have analyzed postoperative pain and analgesic consumption, and yet most only identified the influential correlates in the analysis, but failed to put the statistical model in an independent test to evaluate its accuracy in prediction. This study presents a real-world application of data mining techniques to pain medicine, and considers a wider variety of predictive factors, including PCA demand behavior over time. We extend previous works by proposing a multi-strategy approach that combines clustering, classification, and regression to predict analgesic consumption. To evaluate the performance, we conducted the cross-validation test to compare it with other regression methods. In addition, we compared the computational approach with human experts in an independent test. The results of both tests have verified the feasibility of the proposed computational method, and demonstrated its superiority over other regression tools and human domain experts.

Keywords: patient-controlled-analgesia, inductive inference, regression, clustering, classification

1. Background and Goals
Pain is one of the most commonly reported postoperative symptoms (Chung et al., 1996). It can negatively affect quality of life, and may do more harm than an illness itself when it becomes intolerable, making the patient both physically and mentally uncomfortable. Pain is a highly personal experience influenced by multiple factors, including sensitivity to pain, age, genetics, physical status, and psychological factors (Turk & Okifuji, 1999; Bisgaard et al., 2001). With the progress of medical science, people have gradually become aware of the importance of pain management. According to the research (Walder et al., 2001; Dolin et al., 2002), PCA (Patient Controlled Analgesia) is one of the most effective techniques for postoperative analgesia, and is widely used in hospitals for the management of postoperative pain, especially for major surgeries.

While many works on postoperative pain management have been conducted, most are limited to evaluating the correlation of patient characteristics with postoperative pain intensity or analgesic requirement (Gagliese et al., 2008; Chia et al., 2002; Pan et al., 2006). Several positive correlates, such as age and gender, have been found; however, their $R^2$ (coefficient of determination) are small (Pan et al., 2006). These findings suggest that other predictive factors are present, and have not been analyzed. In this study, we analyze PCA-related factors in addition to demographic and physiological attributes. We considered PCA demand behavior patterns, and combined them with regression to construct the computational models for analgesic consumption prediction. The goal is to predict the total analgesic consumption of the patient based on demographic features, physiological states, and the first few hours of PCA usage data. To demonstrate the performance, we tested the trained models on real PCA patients, and compared them with other computational tools and medical doctors. The results show that the proposed prediction models outperformed all the other computational methods and the human experts in accuracy, which verifies the feasibility of the computational methods.

2. Methods
The Abbott Pain Management Provider (Abbott Lab, Chicago, IL, USA) was used for PCA treatment. PCA usage profiles from 2009 to 2014 were collected from Changhwa Christian Hospital (CCH) for analysis. With the assistance of the Acute Pain Service at CCH, more than 5,000 patient records dated from 2009 were retrospectively collected. After discarding incomplete PCA log files and patient records with missing demographic, biomedical, or surgery-related attributes, we finally obtained 3,052 patient records. From CCH, each patient record contained attributes such as basic health status, age, gender, weight, etc. Table 1 presents the attributes of a patient, which are divided into three categories: (a) patient demographic attributes, (b) biomedical attributes, and (c) operation-related attributes.

Most previous regression studies of postoperative pain and PCA analgesic consumption used $R^2$ (coefficient of determination) to evaluate the learned regression model without testing it on
an exclusive test data set (Chung et al., 1996; Bisgaard et al., 2001; Chang et al., 2006; Walder et al., 2001; Pan et al., 2006). Unlike previous works, from the physical states of the patients, and their first few hours of PCA treatment profiles, our goal is to learn a computational model to predict the total anesthetic dose taken in subsequent hours. By addressing the analgesic consumption prediction in analogy to an inductive inference problem, we measured the performance of the predictive method trained from the training data by its root mean squared errors (RMSE) in the test data set. Under the framework of inductive inference, we first learn a prediction model from a training set of patient records, and then use the learned model to predict the analgesic consumption of a new PCA patient based on his (or her) observable attribute values. Inspired by the ideas of model trees (Quinlan, 1992) and meta decision trees (Todorovski & D’zeroski, 2003), we developed a Multi-model Regression Tree approach for analgesic consumption prediction.

![Diagram](image)

**Figure 1:** An example of multi-model regression tree $T_r$. P is a pattern attribute, which has two pattern values $p_1$ and $p_2$, and C is a class attribute, which has two class values $c_1$ and $c_2$. Both are model attributes. Three leaf nodes exist in $T_r$. They represent different regression models, $R_1$, $R_2$ and $R_3$, respectively. To select a regression model to predict the analgesic consumption of a patient, we traverse the tree from the root to a leaf along with the pattern and the class values of the patient.

We represent a prediction model in the form of a tree $T_r$, as shown in Figure 1, in which each node, including the root and the leaves, is associated with a model attribute. Each internal node specifies a test of some model attribute, and each branch descending from the node corresponds to one of the possible values for the attribute. Each leaf node specifies a regression model used to predict the analgesic consumption. To predict the analgesic consumption of a new patient, we traverse the tree from its root by testing the attribute at each internal node on the path, and moving down the branch corresponding to the attribute value of the patient until we reach some leaf. The leaf node designates a particular regression model to make the prediction based on the values of the patient attributes (Table 1). Unlike the conventional regression trees (Loh, 2006) that only represent a single regression model, a multi-model regression tree combines multiple regression models into a single tree. A leaf node of a multi-model regression tree indicates which regression model to apply to make the regression prediction.

Take the multi-model regression tree $T_r$ in Figure 1 for example. For a new patient with pattern...
and classified as $c_1$, Tree $T_r$ suggests to use regression model $R_1$ to predict the analgesic consumption. In contrast, for a different patient with pattern $p_2$, Tree $T_r$ suggests to use regression model $R_3$ to predict the analgesic consumption.

There are two types of model attributes for an internal node. One is pattern attribute, which are produced by clustering the patient demand behaviors into groups. The number of values for a pattern attribute depends on the number of clusters identified from the patients, and its values are denoted by indices, e.g. $p_1$ and $p_2$ in Figure 1. The other is class attribute, which are produced by trained classifiers. Their values are the possible classifications predicted by the classifiers.

To characterize different PCA demand behaviors, we retrieved the PCA demand data from each patient’s PCA treatment log file, and derived two types of PCA profiles based on: (a) the number of successful PCA demands in each hour, and (b) the PCA dose in each hour. Following (Hu & Ku, 2012), we adopt the k-medoids (Reynolds et al., 2004) algorithm to partition the patients into clusters according to their PCA demand behaviors, using the Euclidean distance to measure the similarity between two PCA demand profiles. A medoid is a real data point that has the minimum average distance from all other points in the same cluster. The demand profiles grouped into a cluster demonstrate similar demand behaviors, and the medoid, denoted by $\mu$, of a cluster presents the representative behavior pattern over time for that cluster. We assign an index to the patients in the same cluster, e.g. pattern=$p_1$, which indicates to which behavior pattern group these patients belong. By applying k-medoids to different PCA demand profiles, we generate different demand pattern attributes. The class attribute associated with an internal node is defined by a trained classifier, e.g. the naïve Bayesian classifier (Domingos & Pazzani, 1996), and its values are categorical.

To prepare the training data for the classifiers, we categorize the available patient data into...
classes, e.g. $c_1$ and $c_2$, based on their analgesic consumption. To discretize analgesic consumption, we divide the numeric amount into several intervals, with each interval corresponding to a specific class. To keep the consistency with PCA behaviors, we set the number of intervals to the number of behavior patterns, and apply k-medoid to analgesic consumption to identify the intervals. Based on the intervals, we prepare the pre-classified training patient data to train different classifiers, and use the trained classifiers to define different class attributes, respectively. The generation processes of pattern and class model attributes are illustrated in Figure 2.

![Diagram](image)

**Figure 2: Generation process of model attributes.** (a) pattern model attributes, (b) class model attributes

Like the internal nodes, there are also two types of model attributes for a leaf node, depending on the type of regression model associated with the leaf. One is pattern-based regression attribute, and the other is class-based regression attribute. We train a pattern-based regression model from the patients with a specific demand pattern. For example, if we identify two demand patterns from the profiles of successful PCA demands in each hour over time, we train two separate regression models from the patients revealing the two different demand behavior patterns, respectively. Similarly, we train different class-based regression models separately from the patients with different classifications predicted by some classifier. From various demand behavior patterns and trained classifiers, we can derive different regression models. The motivation behind employing different types of regression models in a single regression tree is that in addition to the basic patient attributes in Table 1, we can incorporate different background knowledge such as demand patterns or consumption classifications into prediction models to increase the accuracy of regression. We show the generation process of regression
model attributes in Figure 3.

We adopt a greedy top-down, recursive strategy to build a regression tree from a training patient data set, utilizing the model attributes as the meta knowledge in the regression tree. The core algorithm for building a regression tree is to select the best model attribute for an internal node, and partition the data available at the node into subsets according to the attribute values to create the descending nodes. This process is repeated for the data associated with each descendant to select the next model attribute to grow the tree until some stopping criterion is satisfied.

We adopt a validation-based approach for attribute selection. We first divide the available data \( D \) at a node into a training data set \( T \) and a disjoint validation data set \( V \), where \( D = T + V \). From the training data \( T \), we apply k-medoids to different demand profiles to generate various pattern attributes, and train different classifiers to define various class attributes. From the patients in the training data \( T \) that show different demand patterns and consumption classifications, we learn different pattern-based and class-based regression models, respectively. To select the best model attribute for an internal node, we test each pattern attribute and class attribute, denoted by \( A \), separately by sorting the validation data \( V \) into subsets \( S_1, S_2, \ldots, S_t \) according to \( A \)'s values. When \( A \) is a pattern attribute with \( t \) indices (i.e. \( t \) different patterns for
we check each patient in $V$, and assign him (or her) to subset $S_j$ if his (or her) demand behavior profile is closest to cluster medoid $\mu_j$. In case $A$ is a class attribute, a patient in $V$ is assigned to subset $S_j$ if his (or her) analgesic consumption is classified as $c_j$ by class attribute $A$’s classifier.

For each subset $S_i \subseteq V$, according to the values of model attribute $A$, we apply the pattern-based regression model or the class-based regression model trained from $T$ to predict $S_i$’s analgesic consumption. We denote the regression model by $\text{Reg}_{Ai}$, and the RMSE by $\text{RMSE}(\text{Reg}_{Ai})$. In addition, we also train a linear regression model from $T$ as a base regression model, denoted by $\text{Reg}_{\text{base}}$, and use it to predict $S_i$’s analgesic consumption, denoted by $\text{RMSE}(\text{Reg}_{\text{base}})$. We compare $\text{RMSE}(\text{Reg}_{Ai})$ with $\text{RMSE}(\text{Reg}_{\text{base}})$, and select the regression model with smaller RMSE for $S_i$, denoted by $\text{Reg}_{S_i}$. Based on the validation results on $V (V = S_1 + S_2 + ... + S_t)$, we can measure the worth of the model attribute $A$ by the sum of the RMSE($\text{Reg}_{S_i}$) for each subset, denoted by $\Sigma_i \text{RMSE}(\text{Reg}_{S_i})$. Lower $\Sigma_i \text{RMSE}(\text{Reg}_{S_i})$ indicates higher worth of attribute $A$.

Assuming attribute $A^*$ has the highest worth, and has $u$ values, whether the subsets $S_1$, $S_2$, ..., $S_u$ of $D$ that correspond to $A^*$’s values can form the descending nodes of $D$ depend on the node-splitting criterion: $\text{CV}(\Sigma_i \text{RMSE}(\text{Reg}_{S_i}), A^*, D)$ is significantly smaller than the baseline RMSE, that is $\text{CV}(\Sigma_i \text{RMSE}(\text{Reg}_{\text{base}}), A^*, D)$, for $D$ based on a paired $t$-test over a cross-validation. If this criterion is satisfied, the subsets $S_1$, $S_2$, ..., $S_u$ of $D$ become the new nodes in the tree, and we perform the same training-validation procedure on the descendant nodes recursively to grow the tree. Otherwise, we stop splitting the node, and make $D$ a leaf. As a result, the regression model found previously to minimize the RMSE for $D$ is associated with this leaf node, and used to predict analgesic consumption.

3. Results

We demonstrate the performance of the proposed data mining approach in two aspects: (a) compared with other computational methods, and (b) compared with human domain experts.

3.1 Learning Model Attributes for Internal Nodes in Multi-Model Regression Trees

We applied the k-medoids clustering algorithm to two types of PCA profiles from the patient data: (a) the number of successful PCA demands in each hour, and (b) the PCA dose consumed in each hour. We identified two distinct patient groups revealing markedly different behavior patterns in the PCA profiles, as shown in Figure 4. Patients in the same group show a similar successful demand pattern that is different between different groups. We show the average successful demand profile and the average PCA dose profile in each group in Figures 4(a) and 4(b) for comparison. These patterns were used to define pattern model attributes.

We applied five classifiers to create class attributes, including naïve Bayesian classifier (NB)
(Domingos & Pazzani, 1996), logistic regression (LogReg) (Gnanadesikan & Wilk, 1989), artificial neural network (ANN) (Bishop 1996), decision tree (DT) (Quinlan, 1993), k-nearest-neighbor classifier (k-NN) (Cover & Hart, 1967). To prepare the pre-classified training data to train the classifiers, we discretized the analgesic consumption of the training patient data into two classes. We trained the classifiers from the pre-classified training data to define five class attributes, each of which has two categorical values, \( c_1 \) and \( c_2 \). Figure 5 shows a sample class attribute defined by a DT.

### 3.2 Learning Model Attributes for Leaf Nodes in Multi-Model Regression Trees

The model attributes for the leaf nodes in multi-model regression trees are actually regression models that make predictions. When a test patient traverses along the tree from the root to a leaf, the regression model associated with that leaf node is used to predict the patient’s analgesic consumption. With the pattern attributes and the class attributes, we can partition a training patient data set into subsets according to their attribute values. To exploit the knowledge of demand patterns and consumption classifications in regression analysis, we train regression models from different patients that show distinct patterns or classifications, respectively.

### 3.3 Learning a Multi-Model Regression Tree

From all the model attributes generated, we selected the appropriate ones to construct a multi-model regression tree through a top-down recursive training-validation process. Figure 6 shows a learned tree with eight internal nodes and nine leaf nodes. The internal nodes include six pattern attributes derived from different patient profiles, and two class attributes defined by different classifiers. The nine leaf nodes represent the regression models trained from different patient groups with different patterns and classifications. To save space, we only show the regression model for \( R_1 \).
3.4 Comparison between Multi-Model Regression Trees and Single-Model Regression Tools

The objective of the experiments is to predict the 72-h total analgesic consumption (PCA dose) based on the patient’s demographic attributes, physical states, surgery-related information, and the first 24 h of PCA treatment data. We compared the multi-model regression tree approach with four different regression tools: Support Vector Regression (SVR) (Ho & Lin, 2012), REPTree (Witten & Frank, 2000), stepwise multiple linear regression (LR) (Seber & Lee, 2012), and SMOReg (Shevade et al., 2000). They are the representative regression methods in various fields.
To evaluate the performance, we conducted a 10-fold CV. We randomly divided an initial data set of 3,052 patients into ten disjoint folds (i.e., subsets), each of approximately equal size. We used one fold of data for testing prediction performance, and used the remaining nine folds for training and validation to build a multi-model regression tree. We repeated the same training-validation-testing process for each fold iteratively. To keep the consistency in experiments, we used the same data sets to train and test the other regression tools. We show the results in Table 2. The proposed multi-model regression tree approach outperformed all the other regression tools significantly based a paired t-test over the 10-fold CV.

Figure 6: An example multi-model regression tree learned from training patient data. We show the regression model for $R_1$, in which the dependent variable $y$ is the predicted analgesic consumption. The values of the predictive variables are numerical or categorical. We represent the categorical values of a variable as a bit vector in regression. For example, the first term $-0.9949 * \text{OP class}=1,2,3,4,5,6$ in $R_1$, where $\text{OP class}=1,1,1,1,1,0$, means that if OP class is one of 1~6, the first term is $-0.9949 * 1$.

To evaluate the performance, we conducted a 10-fold CV. We randomly divided an initial data set of 3,052 patients into ten disjoint folds (i.e., subsets), each of approximately equal size. We used one fold of data for testing prediction performance, and used the remaining nine folds for training and validation to build a multi-model regression tree. We repeated the same training-validation-testing process for each fold iteratively. To keep the consistency in experiments, we used the same data sets to train and test the other regression tools. We show the results in Table 2. The proposed multi-model regression tree approach outperformed all the other regression tools significantly based a paired t-test over the 10-fold CV.

### Table 2: Results of 10-fold CV for multi-model regression trees and other regression tools

<table>
<thead>
<tr>
<th>Multi-model Regression Tree</th>
<th>LR RMSE(mg)</th>
<th>REPTree RMSE(mg)</th>
<th>SMORreg RMSE(mg)</th>
<th>SVR RMSE(mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSE(mg)</td>
<td>5.78</td>
<td>9.31*</td>
<td>9.82*</td>
<td>9.50*</td>
</tr>
</tbody>
</table>

*Multi-model Regression Tree is significantly better in a paired t-test over 10-fold CV.*
3.5 Comparison between multi-model regression trees and human domain experts

Ten anesthesiologists or medical specialists at CCH participated in the comparative study. Because it takes 24 h of observation before the anesthesiologists at CCH make the first necessary adjustment of PCA settings, unlike the longer-period comparison among computational models, the goal of this experiment was to predict the 24-h total analgesic consumption (PCA dose) based on the patient’s demographic attributes, biomedical states, operation-related information, and the first 12 h of PCA treatment data. We first trained a multi-model regression tree from 2,992 patient records selected randomly from the data set, and compared it with the human experts in prediction accuracy based on an independent test set of the remaining 60 patients. Table 3 presents the RMSEs of the learned regression tree and of the human experts. They are averaged over the test patients. The final row of Table 3 shows the ranks of the prediction accuracy according to the RMSE. The results indicate that the multi-model regression tree outperformed the human experts on the test patient set, which demonstrates the feasibility of data mining for analgesic consumption prediction.

<table>
<thead>
<tr>
<th>Tree</th>
<th>E1</th>
<th>E2</th>
<th>E3</th>
<th>E4</th>
<th>E5</th>
<th>E6</th>
<th>E7</th>
<th>E8</th>
<th>E9</th>
<th>E10</th>
</tr>
</thead>
<tbody>
<tr>
<td>RMSE</td>
<td>3.54</td>
<td>4.16</td>
<td>4.15</td>
<td>4.03</td>
<td>4.05</td>
<td>4.12</td>
<td>12.8</td>
<td>4.59</td>
<td>4.3</td>
<td>3.98</td>
</tr>
</tbody>
</table>

4. References


Reynolds, A. P., Richards, G., & Rayward-Smith, V. J. (2004). The Application of K-medoids and PAM to the Clustering of Rules. The Fifth International Conference on Intelligent Data Engineering and Automated Learning, 173
The Selecting Algorithm of Monitoring CCTV Camera in Smart Care Surveillance System

Kiyong Kim*
Electronic Engineering, Kyonggi University, South Korea
eye4eye@kyonggi.ac.kr

Eunsung Park
Electronic Engineering, Kyonggi University, South Korea
gecrash@kyonggi.ac.kr

Dongsu Seong
Electronic Engineering, Kyonggi University, South Korea
dssung@kyonggi.ac.kr

Keonbae Lee
Electronic Engineering, Kyonggi University, South Korea
kblee@kyonggi.ac.kr

Background/ Objectives and Goals
In this paper, we describe the algorithm to select proper cameras for tracking client in the smart care surveillance system using CCTV cameras. In the previous system, control server selects the nearest available cameras by sorting the distance between all cameras and clients whenever receiving client's location information. However, this method has the disadvantage that the calculating time to select the nearest camera is increased with the more cameras and clients. Therefore, we propose the method which selects the nearest camera by sorting the adjacent cameras of the last camera to monitor client and dealing with emergency situation. As the experimental results with the proposed method, the time to select the proper camera can be saved comparatively with the previous method.

Methods
Smart care surveillance system provides the service to control the CCTVs to deal with their emergency situation by receiving the location information from the client terminals, such as smart phones. The system consists of control server to control a number of cameras, gateway, victim clients, and helper clients.

The location information sent from victim(client) terminals is transferred to the control server via the gateway. The server finds and controls the nearest cameras to clients, and monitors and
tracks them. And then it sends the location information of the clients to helper terminals, and deals with the emergency situations. In the previous algorithm to select the nearest camera, the server sorts the distance between all cameras in system and clients, and then selects the nearest camera whenever receiving the location information of clients. However, this method has the disadvantage that the calculating time to select the nearest camera is increased with the more cameras and clients. Therefore, we propose the method to select camera by sorting the distance from only adjacent cameras of the last camera to monitor clients.

**Expected Results/ Conclusion/ Contribution**

In this paper, we propose the algorithm to select the nearest camera to victim clients in the smart care surveillance system. The clients send their location information periodically. At this time, they can’t move far away from the previous position. Therefore, when the server receives the location information of the clients, this information is similar to previously received one. It is likely to be that the nearest camera to the following location of client is one of the adjacent cameras of camera monitoring currently. Therefore, if the server calculates the distance between only adjacent cameras of the previously monitoring camera to clients, the computing time is shortened.

The area used for simulation is shown in [Figure 1]. The size of area is 16km\(^2\), and divided into 400 blocks consisting of 20 blocks with horizontal and vertical individually. And then one camera is placed in any position in the block. At this time, the positions of cameras are assigned randomly to a distance of at least 50m between cameras. And the adjacent cameras that are used in the proposed method are limited within 600m radius of the currently monitoring camera.

![Figure 1 The allocated area for the simulation, and placed cameras](image)

The location information of victim clients is chosen randomly in entire area, and next places are specified by up to 5m in all directions from the previous location in every two seconds. In
this way, we compare the two times required for calculation of the nearest camera to clients using entire cameras in system and using only adjacent cameras of the previously monitoring camera. The number of victim clients is increased from 10 people up to 200 people, and the average values of the time spent for searching the nearest camera over 100 times are shown in [Figure 2]. As the simulation results with our method which calculate distance using only the adjacent cameras of previous selected camera, the calculation time of about 85 percent is saved comparatively with the previous method which calculates distances using entire camera in the system.

![Figure 2 The comparison of two methods to select the nearest camera to clients.](image)

Keywords: CCTV, Smart Surveillance System, GPS
ICEAI-1090
Secure Localization with Improved Centroid Method over Wireless Sensor Networks

Shao-I Chu, Yao-Chuan Hsu
Department of Electronic Engineering,
National Kaohsiung University of Applied Sciences, Taiwan
E-mail address: erwinchu@kuas.edu.tw

Shih-Hao Wang
Department of Electronic Engineering,
National Kaohsiung University of Applied Sciences, Taiwan
1103305121@gm.kuas.edu.tw

Chih-Yuan Lien
Department of Electronic Engineering,
National Kaohsiung University of Applied Sciences, Taiwan
109910812@gm.kuas.edu.tw

Yao-Yu Jhuang
Department of Electronic Engineering,
National Kaohsiung University of Applied Sciences, Taiwan
freedomzala2260@gmail.com

1. Background/ Objectives and Goals
Localization or target tracking is one of the most interesting applications and issues in wireless sensor networks (WSNs). It can be applied to various applications such as environment-monitoring, smart home, internet of things (IoT) and so on. Measurement metrics for location estimation include time of arrival (TOA), time difference of arrival (TDOA), angle of arrival (AOA), and received signal strength indicator (RSSI). The technique by using the signal strength is a simple solution when the low-cost and easy-to-implement issues are taken into account. IEEE 802.11 and IEEE 802.15.4 support the function of measuring RSSI in their protocols. When more location-dependent services become popular, the mechanisms preventing the location information from malicious attacks are stringent.
The objectives of this paper are to analyze the estimation errors of the well-known localization algorithms in an unsecure network environment and to design the innovative localization technique, which takes the independent attacks and wireless channel characteristics into consideration.

2. Methods

The proposed approach is mainly composed of three parts:

Step 1) Trilateration: The RSSI measurements for possible three nodes are used for estimate the locations. Let the locations of three anchor nodes be \((x_i, y_i), i=1, 2, 3\). The coordinate of the unknown node is \((x_0, y_0)\). Denote the distance between anchor node \(i\) and the unknown node as \(d_i\). By the distance formula, we can derive

\[
2(x_i - x_0)x_0 + 2(y_i - y_0)y_0 = x_i^2 + y_i^2 - d_i^2,
\]

\(
2(x_j - x_0)x_0 + 2(y_j - y_0)y_0 = x_j^2 + y_j^2 - d_j^2,
\)

The estimated location of the unknown node is obtained.

Step 2) Voting mechanism: The theory of triangulation is applied to filter out the unreliable estimated locations. Let \(d_{ij}\) be the distance between anchor node \(i\) and \(j\). Consider anchor node \(i\), anchor node \(j\) and the unknown node. They should satisfy the relationship as follows:

\[
|d_i - d_j < d_{ij} < d_i + d_j. \tag{3}
\]

As the estimated location meet the condition in (3), this estimated location get one vote. Among the estimated locations, some locations with high votes are chosen as the reliable estimates.

Step 3) Centroid Method: The centroid of the reliable estimation locations are computed. Let \((x_{0,k}, y_{0,k})\) be the estimated locations of the unknown node by using the \(k\)th combination of possible three nodes. Assume that there are \(M\) reliable estimates. The centroid of the estimated locations is

\[
(x_{0}^C, y_{0}^C) = \left( \frac{\sum_{k=1}^{M} x_{0,k}}{M}, \frac{\sum_{k=1}^{M} y_{0,k}}{M} \right). \tag{4}
\]

Compute the distance between the centroid and the location estimate \(k\) as \(d_{C,k}\).
Select $M/2$ reliable estimate locations with the shortest $d_{c,k}$. Finally, the centroid of the $M/2$ locations is computed and acts as the *good* estimated location.

3. Expected Results/ Conclusion/ Contribution

Two simulation scenarios are studied. Scenario 1 investigates the effects of the anchor nodes, and Scenario 2 evaluates the influence of the malicious nodes. Here, the variance of the Gaussian noise is set to be 1. In Fig. 1, it is observed that the prediction error improve when the total number of the anchor nodes increases. Fig. 2 reveals that the estimation errors become severe as the total number of the malicious nodes increase. In these cases, the results show that the proposed centroid method has the best performance.

Keywords: Attack, secure localization, wireless sensor networks
ICEAI-1104
A Design of IT2-Based Granular Classifier from Numerical Data with Degree Information of Class Membership

Myung-Won Lee, Keun-Chang Kwak*
Department of Control and Instrumentation Engineering, Chosun University, Korea
E-mail address: kwak@chosun.ac.kr

Abstract
In this paper, we propose a method for designing Interval Type-2 (IT2)-based Granular Classifier (IT2GC) from numerical data points with degree information of class membership. For this purpose, we complete a Fuzzy K-Nearest Neighbor (FKNN) class assignment that produces the corresponding degrees of class membership on the basis of context-based fuzzy clustering algorithm. In order to demonstrate the classification performance, we utilize a database of machine learning repository for voice disorder detection of Parkinson's patients. This database includes 23 Parkinson's patients and 8 healthy persons with voice features and two classes. The experimental results on the database revealed that the proposed granular classifier showed good classification performance in comparison to previous well-known classifiers.

Keywords: Interval Type-2 fuzzy, granular classifier, fuzzy k-nearest neighbor, context-based fuzzy clustering, Parkinson’s disease

1. Introduction
Parkinson's Disease (PD) is a degenerative disorder of the central nervous system that often impairs the sufferer’s motor skills, speech, and other function. Especially in its early stages, this disease can be difficult to diagnose accurately. Thus, the effective techniques based on artificial intelligence or machine learning are needed to increase the diagnosis accuracy and to help physicians make better decisions. These literatures have demonstrated the effectiveness of diagnosis based on intelligent classifier. Furthermore, the diagnosis studies of PD have been performed to detect voice disorder from speech signals [1-5].

In this paper, we propose design method of Interval Type-2 (IT2)-based Granular Classifier (GC) based on voice feature database of PD patients and healthy people for diagnosis of PD. The underlying architecture of this classifier is based on the variant of Linguistic Model (LM) proposed by Pedrycz [6-8]. Although the effectiveness of this model has been demonstrated in previous works, it needs to be improved from some point of view. First, the context-based fuzzy clustering used in the design of LM is not suitable in the design of classifier, because the membership value corresponding to each context is always 1.
That is, this is equal to perform only fuzzy c-means clustering with data points collected by each class. Furthermore, this problem does not possess the characteristics representing a level of involvement of some data point in the assumed context. For this purpose, we perform a Fuzzy K-Nearest Neighbor (FKNN) [9][10] class assignment that produces the corresponding degrees of class membership on the basis of context-based fuzzy clustering algorithm with the aid of information granulation. Second, the uncertainty of fuzzification factor that controls the amount of fuzziness needs to be considered. In order to deal with this uncertainty, we develop an improved clustering preserving the homogeneity in the input-output space and covering on the uncertainty associated with fuzzification factor by using IT2 fuzzy concept[11][12]. In order to confirm the performance, we use voice disorder detection of Parkinson's patients of UCI machine learning repository [13][14]. This database consists of 23 Parkinson's patients and 8 healthy persons with voice features. The experimental results on this database revealed that the proposed approach showed good diagnosis capability in comparison to the previous works.

This paper is organized in the following fashion. In Section 2, the procedure of context-based IT2 fuzzy clustering is described. The entire design process of IT2-based granular classifier and FKNN class assignment are presented in Section 3. The experimental results are performed and discussed in Section 4. Concluding comments are covered in Section 5.

2. Context-based IT2 fuzzy clustering

The context-based Interval Type-2 (IT2) fuzzy clustering is proposed in this Section. The estimation method of cluster center is similar to the procedure of CFCM (Context-based Fuzzy C-Means) clustering except for adding uncertainty of fuzzification factor \( m \) on the basis of IT2 fuzzy approach. This clustering algorithm is conducted by the following stages [12].

[Step 1] Select the number of context \( (p) \) and cluster \( (c) \) per context, respectively. It assumes that the number of \( (c) \) per context is equal. Initialize the membership matrix \( (U) \) with random value between 0 and 1.

[Step 2] Generate contexts with triangular membership function using uniform distribution in the output space. Each context is generated by an overlap of 0.5 membership degree between successive fuzzy sets as shown in Fig. 1. In the design of classifier, the number of context is equal to the number of class. In general, because the class number is integer, the fuzzy membership value corresponding to each context is always 1. In order to solve this problem, we shall consider FKNN class assignment in the Section 3.
[Step 3] Compute upper and lower partition matrices as Eq. (1) and (2). The fuzzification factor \( m \) is replaced by \( m_1 \) and \( m_2 \) which represent different fuzzifier value.

\[
\bar{u}_{ik} = m \alpha \left\{ f_i \left/ \sum_{j=1}^{\xi} \left[ \frac{\| x_k - c_i \|}{\| x_k - c_j \|} \right] \right\}^{\frac{2}{m_1-1}}, f_x \left/ \sum_{j=1}^{\xi} \left[ \frac{\| x_k - c_i \|}{\| x_k - c_j \|} \right] \right\}^{\frac{2}{m_2-1}} \tag{1}
\]

\[
u_{ik} = \min \left\{ f_k \left/ \sum_{j=1}^{\xi} \left[ \frac{\| x_k - c_i \|}{\| x_k - c_j \|} \right] \right\}^{\frac{2}{m_1-1}}, f_x \left/ \sum_{j=1}^{\xi} \left[ \frac{\| x_k - c_i \|}{\| x_k - c_j \|} \right] \right\}^{\frac{2}{m_2-1}} \tag{2}
\]

where \( f_x \) denotes a level of involvement of the \( k \)'th data point in the assumed context.

[Step 4] Update the cluster center. The individual values of the left and right cluster boundaries in each dimension can be computed by sorting the order of patterns in particular dimension and then applying Karnik-Mendel (KM) iterative procedure [15]. Here KM algorithm is used to update the interval set of cluster centers. The new cluster center is computed by a defuzzification method as follows

\[
c = \frac{c_L + c_R}{2} \tag{3}
\]

[Step 5] Compute distance measure between the updated clusters and the previous ones. Stop if the improvement over previous iteration is below a certain threshold.


\[
u_{ik} = \frac{\bar{u}_{ik} + \nu_{ik}}{2} \tag{4}
\]
3. IT2-based granular classifier

In this Section, we use FKNN algorithm to obtain a level of involvement of some data point in the assumed context. The computations of the membership degrees are realized through a sequence of steps [10].

[Step 1] Compute the Euclidean distance matrix between pairs of feature vectors in the training.

[Step 2] Set diagonal elements of this matrix to infinity.

[Step 3] Sort the distance matrix in an ascending order. Collect the class labels of the patterns located in the closest neighborhood of the pattern under consideration.

[Step 4] Compute the membership grade to class “i” for j’th pattern using the expression proposed in the literature.

\[
\mu_{ij} = \begin{cases} 
0.51 + 0.49(n_{ij}/k), & \text{if } i = \text{the same as the label of the } j\text{-th pattern} \\
0.49(n_{ij}/k), & \text{if } i \neq \text{the same as the label of the } j\text{-th pattern}
\end{cases}
\] (5)

In the above expression, \(n_{ij}\) stands for the number of the neighbors of the j’th data point that belong to the i’th class. After the examination of the membership allocation formula we conclude that the method attempts to “fuzzify” or refine the membership grades of the labeled patterns. The “dominant” membership has not been affected yet we end up with some refinement of membership grades. Intuitively, if there are very few neighbors of the pattern that belong to the same category, the membership grade is kept close to 0.51. Thus, the \(\mu_i\) of Eq. (5) is used to the \(f_k\) value of Eq. (1) and (2). Fig. 3 shows the architecture of the granular classifier. The output value of each class is obtained by summing \(u_k\) of Eq.(4) computed in each context. The final classification is obtained by finding \(\xi_i\) value with maximum value.
4. Experimental Results

This dataset used in this paper is composed of a range of biomedical voice measurements from 31 people, 23 with Parkinson’s disease (PD). Each column in the table is a particular voice measure, and each row corresponds one of 195 voice recording from these individuals. The main objective of this data is to discriminate healthy people from those with PD. The data is in ASCII CSV format. The rows of the CSV file contain an instance corresponding to one voice recording. There are around six recordings per patient, the name of the patient is identified in the first column. The phonations were recorded in an IAC sound-treated booth using a head-mounted microphone positioned at 8 cm from the lips. Table 1 lists the description of this database. The data set consists of 195 samples. The input variable consists of sixteen, including average vocal fundamental frequency, MDVP jitter, shimmer, noise-to harmonic ratio, etc. The output variable is two classes (PD, non-PD). In order to evaluate the resultant model, we divide the data sets into training and testing data sets. Here we choose 98 training sets for fuzzy classifier construction, while the remaining data sets are used for fuzzy classifier validation.
The proposed granular classifier represented the best results when the number of p and c are 2 and 4, respectively. We compared with RBFC (Radial Basis Function Classifier) and ANFC (Adaptive Neuro-Fuzzy Classifier). In the design of RBFC proposed by Pedrycz[16], we used 8 hidden nodes with two contexts and four clusters showing best performance. Here learning rate is 0.001 and the number of epoch is 1000. On the other hand, we compared with ANFC proposed by Cetisli[17] using linguistic hedges. Table 2 lists the performance comparison of classification performance. As listed in Table 1, the experimental results on PD database revealed that the proposed method showed good performance in comparison to the previous classifiers.
Table 2: Comparison of classification performance

<table>
<thead>
<tr>
<th>Method</th>
<th>Training data set (%)</th>
<th>Testing data set (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RBFC [16]</td>
<td>85.53</td>
<td>74.32</td>
</tr>
<tr>
<td>ANFC [17]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 rules</td>
<td>87.75</td>
<td>82.47</td>
</tr>
<tr>
<td>6 rules</td>
<td>72.44</td>
<td>70.10</td>
</tr>
<tr>
<td>8 rules</td>
<td>72.44</td>
<td>67.01</td>
</tr>
<tr>
<td>10 rules</td>
<td>71.42</td>
<td>62.88</td>
</tr>
<tr>
<td>Granular classifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$p=2$, $c=2$</td>
<td>90.82</td>
<td>87.63</td>
</tr>
<tr>
<td>$p=2$, $c=3$</td>
<td>93.88</td>
<td>89.70</td>
</tr>
<tr>
<td>$p=2$, $c=4$</td>
<td>96.94</td>
<td>93.82</td>
</tr>
<tr>
<td>$p=2$, $c=5$</td>
<td>95.92</td>
<td>91.76</td>
</tr>
</tbody>
</table>

5. Conclusions
We have proposed the interval type-2 based granular classifier from numerical data points with degree information of class membership for voice disorder detection of Parkinson's patients. For this, we used a fuzzy k-nearest neighbor class assignment that produces the corresponding degrees of class membership on the basis of context-based fuzzy clustering algorithm. Furthermore, we developed the clustering algorithm preserving the homogeneity in the input-output space and covering on the uncertainty associated with fuzzification factor by using IT2 fuzzy concept. The experimental results revealed that the proposed granular classifier showed good classification performance in comparison to previous RBFC and ANFC. For further research, we shall develop the design and optimization of granular classifier based on evolutionary algorithm.

6. Acknowledgements
This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science, ICT and Future Planning (NRF-2013R1A1A2012127)

7. References
ICEAI-1115
Automatic Exudate Classification in Diabetic Retinopathy Images Using Neural Network

Ratikanlaya Tanthuwapathom*
Image, Information and Intelligence Laboratory, Department of Computer Engineering,
Faculty of Engineering, Mahidol University, Thailand
E-mail address: t.ratikanlaya@gmail.com

Narit Hnoohom
Image, Information and Intelligence Laboratory, Department of Computer Engineering,
Faculty of Engineering, Mahidol University, Thailand
E-mail address: narit.hno@mahidol.ac.th

Abstract
At present, it is found that all over the world there are 371 million patients suffering from diabetes, which is hereditary. It is expected that in year 2030 there will be 500 million people with diabetes. A recent survey revealed that 22 percent of diabetic patients have diabetic retinopathy and can lead to blindness in later times. Therefore, diabetic patients should have their eyes check-up at least once a year. Thus, researches on screening for diabetic retinopathy have been of interest and constantly developing by using digital image processing method. This paper presents the detection of exudates by finding Optic Disc (OD) with morphological method and cutting it (exudates detection) out of the background with local thresholding method. This paper also proposes a feature classifying images of retina of patients with exudates. From the experiment with all 179 sample images, we achieved a 96.72% correct exudate detection.

Keywords: Exudate, Optic Disc (OD), Fundus image, Microaneurysms, Retinal hemorrhages

1. Background/ Objectives and Goals
Diabetic retinopathy has been found many patients in the world. It also found that a person with diabetes losing eyes possibility is up to 20 times more than ordinary people. The studies found that patients with less than 10 years of diabetes have the risk of having the diabetic retinopathy at 7%. However, the risk would increase to 63% for patients with more than 15 years of diabetes. Anyway, patients with well glucose control can still have diabetic retinopathy in the longer term or older age. Therefore, patients with diabetes should be checked their optical health at least once a year. Therefore, the detection of abnormalities in the retina of diabetic patients is significant for treatment. However, in Thailand there are not enough ophthalmologists for diabetic patients. Therefore, creating disease diagnosing system will
allow doctors to work more quickly and help patients not to lose their eyes according to the delayed detection of diabetic retinopathy conditions. Types of lesion we found were such as microaneurysms, retinal hemorrhages and exudates [1]. In this paper, we executed exudate detection due to the different color to the retinal fundus.

To detect a thick greasy substance, firstly, we would detect and subtract the optic disk with morphological method to avoid noise in the exudate detection. After eliminating optic disk from the image of retina, the thick greasy substance was extracted. Only green channel of RGB color model was used for detection. Then, the green channel would be segmented by adaptive thresholding process. A good segmentation based on an appropriate thresholding selection. When we obtained the thick greasy substance, its feature would be considered for training with neural network. The system was tested by all 50 images of retina and 129 training images.

This research has it objective and goal to detect exudates from retinal images and select a proper feature to classify exudate. It also can be a guideline for other developers who engage in researches on diabetic retinopathy screening.

The rest of paper is organized as follows: section 2 expands propose methods. Finally results and discussions are described in section 3.

2. Methods

In this section, the methodology for exudate detection is composed of four main stages: image acquisition, pre-processing, exudate extraction, and exudate classification.

![Block Diagram of our framework](image)

2.1 Image Acquisition

In the first phase of the exudate detection is the image acquisition. The fundus images were collected from Institute of Medical Research and Technology Assessment. The image data were converted in the JPEG file format with size 813×499, 229 images in totals, 179 images as a training set and 50 images as a test set.

2.2 Preprocessing

This preprocessing is to prepare the image data for using in a decision support system. The pre-processing is composed of three stages: resize images and blur images, conversion to HSV color model and RGB color model.
1) Resize Images and Blur Images
Input images were resized to be 512×512 so that images with different sizes did not affect the system functionality. Then, blurred images to adjust the color of the images at the same level.

2) Conversion to HSV Color Model
This process is used to find hue, saturation, and value, due to HSV model had more resolution than RGB color model. Then, we used it for further training part.

3) RGB Color Model
RGB color model is used to analyze lesions. Only green channel was used because this channel could keep most elements of an image with high contrast between blood vessels and optic disk when compared to red channel and blue channel [2, 3, 4, 5] as shown in Figure 2.

![Image](image.png)

**Fig. 2:** (a) Original image (b) Blur image (c) Red channel (d) Green channel (e) Blue channel

2.3 Exudate Extraction
Exudate Extraction is composed of two stages: the process of separating back-ground from retinal images and optical disc detection.

1) The Process of Separating Background from Retinal Images
This process is to separate the image background with the adaptive thresholding segmentation by separating the background from the object of interest into small parts. All parts would be applied by the same thresholding value to separate objects from the background as shown in Figure 3.

![Image](image.png)

**Fig. 3:** Segmentation image using local thresholding with green channel

2) Optical Disc Detection
This process is to erase the retina from the image, leaving only the exudates by morphological
[6, 7, 8]. Opening or expanding the image structure in order to make the image larger. The looks of expanded images depended on the structuring element used to scan on the image. After the dilation, the next process was the erosion to reduce the object size. The looks of eroded images depended on the structuring element used to scan on the image by bringing the expanded image through dilation process to the Erosion process to eliminate the exudates, leaving only the retina. After the closing process, the images would be brought through dilation again to increase the retina size. Then, the images that passed the local thresholding process would be used to delete the image of the retina. As a result, the retina on the image would disappear, leaving only the exudates as shown in Figure 4.

![Fig. 4: Optical Disc Detection](image)

**2.4 Exudates Classification**

Finding the exudates by using K-nearest neighborhood (K-NN) was a very good study for nonparametric and parametric classification techniques and the method was effective. Therefore, this paper adopt the method for the study. On the other hand, if the parameters do not meet the specified parameters, it will be considered to be contaminated by the noise within the image.
This paper uses 13 features in training. Using exudate to find feature value as follows. Area was given by Equation (1), perimeter, solidity by Equation (2), eccentricity by Equation (3), entropy, homogeneity, compactness, major axis length, minor axis length, mean of green channel, standard deviation of the green channel, mean of HSV, and standard deviation of HSV. When we obtained the feature value. [9, 10, 11]

<table>
<thead>
<tr>
<th>No.</th>
<th>Input Images</th>
<th>Output Images</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
</tr>
<tr>
<td>2</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
</tr>
<tr>
<td>3</td>
<td><img src="image5.png" alt="Image" /></td>
<td><img src="image6.png" alt="Image" /></td>
</tr>
<tr>
<td>4</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>

This paper classify exudation by neural network [12], training was a process of using samples to develop a neural network that includes the forms of input with the correct answer. Also, group of samples with known output was sent to the network repeatedly to train the network system. The training process would be carried on until there was the difference between input and output, and the pattern for the training set value was accepted. There were several methods...
for training network, and the Back-propagation was commonly known. The back-propagation could work successfully within two steps. To begin with, input would be sent forward through the network to produce the output. Subsequently, the difference between real output and the expected output would generate an error signal, which returned the value over the network to improve the weight of input.

3. Results
System accuracy was measured by Diabetic retinopathy (DR) numerical index, obtained by total input pixels of exudates subtracted total output pixels of exudates, divided by total input pixels of exudates, and then multiplied by 100 as shown in Equation (4).

\[ DR = \frac{\sum_{i=0}^{N_{\text{input exudate}}} \text{output exudate} - \sum_{i=0}^{N_{\text{output exudate}}} \text{input exudate}}{\sum_{i=0}^{N_{\text{total exudate}}} \text{total exudate}} \times 100 \]  

(4)

In this paper we studied from 229 fundus images dividing into the training set 179 images and the test set 50 images. The accuracy was measured from DR Numerical Index as the results shown in Table 2.

<table>
<thead>
<tr>
<th>Number of data training</th>
<th>Number of data test</th>
<th>Accuracy rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>179</td>
<td>50</td>
<td>96.7%</td>
</tr>
</tbody>
</table>

This paper presented an algorithm for exudate classification from retinal fundus image data sets by neural network. The data sets are separated into two groups for training and testing, respectively. All of 15 features which making accurate results are 96.7%, indicating that it can help ophthalmologists in finding the thick greasy substance to detect diabetic retinopathy. The system can also be developed for use in medical methods. Nevertheless, this presented method has limitation in optical disk extraction that the optical disk image must be clearly seen.

3.1 Acknowledgments and Legal Responsibility
This project is supported by Department of Computer Engineering, Faculty of Engineering, Mahidol University. We would like to thank Institute of Medical Research and Technology Assessment for the database.

4. References


ICEAI-1166
Two-Stage Haze Removal Algorithm with Color Preserving

Chi-Wei Wang
Graduate Institute of Communication Engineering, National Taiwan University, Taiwan
mm412537r@gmail.com

Jian-Jiun Ding
Graduate Institute of Communication Engineering, National Taiwan University, Taiwan
jjding@ntu.edu.tw

Hung-Yi Chen
Graduate Institute of Communication Engineering, National Taiwan University, Taiwan
joey1149@gmail.com

Abstract
Sometimes, an image acquired from a digital camera is affected by the haze or mist, which decreases the clarity of an image. There are some existing image dehazing algorithms. However, it usually happens that a smooth region becomes noisy and the color is changed after dehazing. The proposed method tries to have computational efficiency while keeping quality of dehazed images. We propose a framework that divide the haze-removal procedure into two stages and apply some techniques to remove noise and preserve color. We pick up the guided filter and the edge-preserving smoother to refine the transmission map at both stages. Simulations show that, with the proposed techniques, high quality dehazed images can be acquired.

Keywords: Haze removal; image processing; transmission map; dark channel prior; color preservation

1. Background/ Objectives and Goals
Haze or fog often appears in outdoor images. They are typically caused by suspended particles in the air. This natural phenomenon degrades the qualities of images and affects the performance of object recognition or the image feature extraction. Image dehazing technologies can solve this problem (Narasimhan and Nayar, 2000, 2002, Tan 2008, and Fattal 2008). A remarkable work, the dark channel prior, was proposed in (He et al., 2011). With the dark channel, one can distinguish the hazy part from the normal part and well remove the effect of haze. Then, in (Xiaoand and Gan, 2012), (Gibson and Nguyen, 2013), and (He et al., 2014), the haze removal algorithms based on the bilateral filter and the adaptive Wiener filter were proposed. In (Tarel and Hautiere, 2009), a dehazing algorithm with very less computation time
was proposed.

In this paper, we propose a dehazing framework and try to remove haze as much as possible without color distortion and increasing the effect of noise. We apply the techniques of oversaturation elimination, the posterior filter, the edge-preserving smoother, and border adjusting to improve the quality of dehazed image.

2. Methods

We propose a method that can eliminate tradeoff of haze-removal and color preserving by a novel two-stage schema. A hazy image can be modeled as

\[
I(x, y) = J(x, y)t(x, y) + A(1 - t(x, y))
\]

where \(I\) is the observed hazy image, \(J\) is the scene radiance, \(A\) is the global atmospheric light associated with three color channels, and \(t\) is the intermediate transmission function describing the portion of light that is not affected by haze.

The dark channel prior is based on the observation: In most of the non-sky area, at least one color channel has some pixels whose intensity are very low and close to zero. Therefore, the minimum intensity in such a patch is close to zero. For an arbitrary image \(J\), its dark channel \(J_{\text{dark}}\) is defined as

\[
J_{\text{dark}}(x, y) = \min_{i, \Omega(x, y)} \left( \min_{c \in [r, g, b]} J^c(i, j) \right)
\]

where \(J^c\) is a color channel of \(J\) and \(\Omega(x, y)\) is a local patch centered at \((x, y)\). The dark channel prior is that, except for hazy regions or some light area, the following equation usually holds:

\[
J_{\text{dark}} \rightarrow 0.
\]

The guided filter can reveal the hazy degree of each region, as in Fig. 1. From (1)

\[
\frac{I(x, y)}{A} = t(x, y) \frac{J(x, y)}{A} + 1 - t(x, y).
\]

If we take the dark channel for the observed image \(I\), then from (3) and (4),

\[
I_{\text{dark}} = \min_{(i, j) \in \Omega(x, y)} \left( \min_{c \in [r, g, b]} \frac{I_c(i, j)}{A_c} \right) = 0 + 1 - t(x, y).
\]
\[
\tilde{t}(x, y) = 1 - w \cdot I^{avg}
\]  

(6)

where \( w = 0.9 \) is to control tradeoff between the performance of haze-removal and preserving of color tones. Then, we can solve the original haze-free image from

\[
J(x, y) = \frac{I(x, y) - A}{\max(\tilde{t}(x, y), t_0)} + A
\]  

(7)

where \( t_0 \) is to prevent \( J \) to be infinite when \( \tilde{t} \to 0 \). Typically we choose \( t_0 = 0.1 \).

The guided filter (He et al., 2013) can be used to further refine the transmission map. Its key assumption is that there is a linear relation between the guidance \( I \) and the filter output \( Q \):

\[
Q = a_k I + b_k \quad \forall i \in \Omega_k
\]  

(8)

where \( a_k \) and \( b_k \) are constant coefficient within \( \Omega_k \) and \( \Omega_k \) is some patch. The above equation ensure that \( Q \) has an edge only if \( I \) has an edge because \( \nabla Q = a \nabla I \). To determine the coefficient, we want to find a solution that minimizes the difference between the output \( Q \) and the input \( P \) under the assumption of local linearity mentioned above. Then, we try to minimize the following cost function within a patch \( \Omega_k \)

\[
E(a_k, b_k) = \sum_{i \in \Omega_k} \left( (a_k I_i + b_k - P_i)^2 + \sigma_k^2 \right)
\]  

(9)

The solution of (9) can be given by linear regression (Draper et al., 2014)

\[
a_k = \frac{1}{|\Omega_k|} \sum_{i \in \Omega_k} I P_i - \mu_k \mu_{P,k} \quad \sigma_k^2 + \hat{\sigma}, \quad b_k = \mu_{P,k} - a_k \mu_k
\]  

(10)

where \( \mu_k \) and \( \sigma_k^2 \) are the mean and variance of \( I \) within \( \Omega_k \), \( |\Omega_k| \) is the number of pixels in a patch, and \( \mu_{P,k} \) is the mean of the input image within \( \Omega_k \). The above guided filer can be used as
an edge-preserving smoother, which is a key point for refining the transmission map $\tilde{r}$ in the haze removal procedure.

Although the dark channel and the guided filter can reduce the effect of haze, some problems exist. The most obvious one is color oversaturation. It is caused by the division in (7) and the limited dynamic range of display, as shown in Fig. 2.

Furthermore, there is a tradeoff between color preserving and haze removing. If we remove haze as much as possible, we would sacrifice original color tones, causing severe oversaturation. To solve these problems, we propose a framework that divide the haze-removal procedure into two stage and perform some filter operations between stages to preserve color. One can pick up any edge-preserving smoother (such as the bilateral filter) to refine the transmission map at both stages.

![Dynamic Range of Display](image)

*Figure 2: Original pixel value after division in (7) may cause oversaturation.*

We first shrink the difference among RGB color channels using a square root operation. That is, for an input hazy image $I$, we calculate the square root value of each pixel to get the image $I_1$ and use $I_1$ as the input of the dark-channel-based haze-removal algorithm in (1)-(7). After calculating the transmission map by (6), we apply the guided filter to refine it. This refinement is required to eliminate halos and block artifacts. We use the result of (6) as the guidance image and use the result of the following equation as input image.

$$
\tilde{t}_m = 1 - w \cdot \left( \min_{x \in (r, g, b)} \frac{I_x}{A_x} \right)
$$

In Fig. 3, we show comparison of such setup and inverse setup.

Then, we can repeat this haze-removal procedure again. That is, assuming that we get the output of the first stage $J_1$. We can perform square root and haze removing on $J_1$ again to get the output $J_2$ of the second stage.

We perform the linear intensity mapping according to the atmospheric light of $J_2$ and the input image $I$. That is, we map intensity of $J_2$ to $I$ linearly based on the difference of atmospheric
light between $J_2$ and $I$. We denote the result after intensity mapping as $J_3$.

To fix oversaturation or too bright areas in $J_3$, we apply a minimum operator on $J_1$ and $J_3$. Furthermore, to preserve haze-free area of input image $I$, another minimum operator is applied again, i.e.,

$$J_{ot} = \min_{\tau_I} \left( \min_{\tau_I} (J_1, J_3), I \right)$$  \hspace{1cm} (12)

In other words, we select better area of each stage by min operators. Moreover, for the patch that the intermediate transmission function $t$ is small, the over-saturation problem is especially obvious at the border of the object after performing conventional image dehazing algorithms. One can perform edge detection and apply color compensation for the large gradient part to solve the problem.

(a) Result of using (6) as the guidance and (11) as the input.

(b) Result of using (11) as the guidance and (6) as the input.
3. Results

In this section some comparisons among existent works are shown. Our method is aimed for removing haze as much as possible while other works may intend to keep some haze for reasons about visual nature. We try to conquer this tradeoff in the proposed algorithm.

Fig. 4 show comparison of proposed method with other works. From Fig. 4(d), we can find that if we remove haze as much as possible without some techniques for preserving color, tone of colors would be changed. Fig. 4(b)(e) remain a little haze for preserving visual nature while Fig. 4(c) subscribes some tones of color for removing haze better. And our method tries to remove all haze and meanwhile preserve color. In Fig. 5, we enlarge a patch of Fig. 4. It is quite obvious that our proposed method has better effect on the haze removal and color tones are preserved better, too.

Fig. 6 is another example. It is noted that some area is haze-free while central part is heavily hazy. In Fig. 7, we enlarge the central part if Fig. 6. It can be noted that our method is good at removing heavy haze while keeping color tones meanwhile.

More simulation results are shown as in Figs. 8 and 9. These results show that the dehazed images of the proposed algorithm have better quality than those of other methods.
Figure 5: Enlarge a patch of Fig. 4 for comparison.

Figure 6: Comparison of the performances of dehazing algorithms.
Figure 7: Enlarge a patch of Fig. 6 for comparison.
Figure 8: Comparison of the performances of dehazing algorithms
In this paper, we propose a novel two-stage haze removal framework for image dehazing and apply the techniques of oversaturation elimination, the posterior filter, the edge-preserving smoother, and border adjusting. Simulations show that the proposed algorithm has much better performance than other existing dehazing methods. It will be useful for improving the quality of the photo images acquired from cameras.

**Acknowledgments**

This work was supported by Qualcomm Technologies Inc.

**References**


ICEAI-1184

Real Time Sensing and Shadow Robustness Video Foreground Segmentation Algorithm

Jian-Jiun Ding
Graduate Institute of Communication Engineering, National Taiwan University
jjding@ntu.edu.tw

Yu-Chen Liu
Graduate Institute of Communication Engineering, National Taiwan University
r03942035@ntu.edu.tw

Yao-Ren Chang
Graduate Institute of Communication Engineering, National Taiwan University
r04942127@ntu.edu.tw

Hung-Yi Chen
Graduate Institute of Communication Engineering, National Taiwan University
joey1149@gmail.com

Abstract
In video processing, it is very important to extract moving objects, i.e., the foreground of a video image. The accuracy and efficiency of moving object extraction highly affect the performance of activity recognition and object tracing. There are several existing video foreground extraction algorithms. However, most of them requires a lot of computation time. Moreover, the shadow part is usually misidentified as the moving object. In this paper, we propose an accurate and efficient algorithm for video foreground extraction. With the techniques of fast scanning, superpixels, and the frame difference at the boundary, the proposed algorithm can detect the moving object in real time and requires very less computation time. Simulations show that the proposed algorithm can very accurately extract the foreground of the video image and is robust to shadows.

Keywords: motion segmentation, fast algorithm, video signal processing, activity recognition, shadow

1. Background/ Objectives and Goals
Foreground extraction plays a very important role for many video analysis applications, such as human activity recognition, sport video analysis, healthcare, security, and surveillance. A real-time and accurate foreground extraction algorithm will be very helpful for these
applications. For example, it would be dangerous to the elders who live alone. If any emergent accident like falling occurs, a healthcare system should detect the accident in real time. Moreover, for security, in order to detect abnormal events in real time, such as leaving a package which might contains dynamite in the airport, the foreground extracting algorithm should be accurate enough and require very less computation time.

There are several existing video foreground extraction algorithms. In (Stauffer and Grimson, 1999) and (Zivkoic, 2004), they used Gaussian mixture models (GMM) to find the background of the video image. For each pixel, there are 3 to 5 Gaussian models with different variances to model the distribution of the pixel values in the same location but different frames. Then, they judge whether an input pixel belongs to the foreground according to whether the difference between the pixel value and the background is larger than the standard deviation. Although GMMs can update foreground in real time, it is easily disturbed by the change of luminance. Shadow and noise-like haze would severely affect the results. In (Cucchiara et al., 2003), they proposed a knowledge-based algorithm to classify the foreground parts. They applied the optical flow to distinguish the shadow part, the ghost part, and the real foreground part. However, the result of the algorithm in (Cucchiara et al., 2003) is noisy especially on the edge parts of the foreground. The common problem in (Stauffer and Grimson, 1999), (Zivkoic, 2004) and (Cucchiara et al., 2003) is that there are holes in the region of interest, which can be viewed as another kind of noise.

In recent years, several algorithms based on robust principle component analysis (RPCA) were proposed (Wright et al., 2009, Lin et al., 2010, Zhou et al., 2013 and Xin et al., 2015). They used low-rank matrices and convex optimization to find the foreground part. The main idea is to transfer video frames into vectors and combine the vectors into a big matrix. Then, one tries to decompose the big matrix into two matrices, which correspond to background and fore-ground. The background matrix is low-rank and the foreground matrix is iteratively calculated from the objective function. Although RPCA-based algorithms have good performance, they require a lot of computation time. Moreover, the results are still affected by noise and the boundaries of the fore-ground are not extracted accurately in many cases.

In this paper, we propose a new algorithm for video foreground extraction. With the techniques of the Lab color space, fast scanning, superpixels, and the frame difference at the boundary, the proposed algorithm can detect the moving object in real time. Moreover, the proposed algorithm is robust to noise and shadow and the boundary of the foreground can be extracted very accurately.

The detail of the proposed algorithm is described in Section 2. Several simulations are per-formed in Section 3. In Section 4, we make a conclusion.
2. Methods

The flowchart of the proposed algorithm is plotted in Fig. 1. For an input image, we first perform the Lab color transform (Schanda, 2007). The Lab color transform is to convert the RGB color space into the Lab color space where $L$ is related to luminance and $a$ and $b$ are related to colors.

If an object is affected by noise, then the values of $a$ and $b$ may be changed but the value of $L$ is nearly unchanged. Therefore, detecting the foreground in the Lab space instead of the original RGB space is more robust to shadow. Then, we calculate frame difference. We use $I(m, n, c, k)$ to denote the pixels of the input video image where $(m, n)$ is the coordinate, $c = L, a, or b$, and $k$ means that the pixel is in the $k^{th}$ frame. Then, instead of calculating the difference of the current frame and the previous one frame directly, we calculate

![Flowchart of the proposed algorithm](image)

**Fig. 1:** The flowchart of the proposed foreground extraction algorithm.
Determining the frame difference from (1) instead of \( I(m, n, c, k) - I(m, n, c, k-1) \) is more robust to noise. Then, we calculate

\[
D_1(m, n, c, k) = I(m, n, c, k) - 0.4 I(m, n, c, k-1) - 0.3 I(m, n, c, k-2) - 0.2 I(m, n, c, k-3) - 0.4 I(m, n, c, k-4) .
\]

(1)

We assign larger weights for the \( a \) part and the \( b \) part to reduce the effect of shadow.

Then, we classify the pixels into two parts: the part where the background has been determined and the part where the background has not been determined. We apply an algorithm that is similar to the fast scanning algorithm in (Ding et al., 2009) to determine whether a pixel is stable within a time interval.

Initially, we set \( C_1(m, n) \) and \( C_2(m, n) = 0 \) for all \( m \) and \( n \). If \( D(m, n, k) \leq \Delta \), then we set

\[
(i) \quad C_{1,\text{new}}(m, n) = C_{1,\text{old}}(m, n) + 1 ,
(ii) \quad C_{2,\text{new}}(m, n) = C_{1,\text{new}}(m, n) .
\]

If \( D(m, n, k) > \Delta \) but \( E(m, n, k) \leq \Delta \) where

\[
E(m, n, k) = (D_2(m, n, L, k))^2 + 4(D_1(m, n, a, k))^2 + 4(D_1(m, n, b, k))^2 ,
D_2(m, n, b, k) = D_1(m, n, c, k-1) - I(m, n, c, k-1) + I(m, n, c, k) ,
\]

then we set

\[
(i) \quad C_{1,\text{new}}(m, n) = C_{2,\text{old}}(m, n) + 1 ,
(ii) \quad C_{2,\text{new}}(m, n) = C_{1,\text{old}}(m, n) .
\]

If \( D(m, n, k) > \Delta \) and \( E(m, n, k) > \Delta \), then we set

\[
(i) \quad C_{1,\text{new}}(m, n) = 1 ,
(ii) \quad C_{2,\text{new}}(m, n) = C_{1,\text{old}}(m, n) .
\]

In the case where \( C_1(m, n) \geq T \), then we can conclude that the pixel value is stable at \((m, n)\) and we will classify \((m, n)\) as the known background part. Then, the background at \((m, n)\) is calculated from

\[
B(m, n, c) = \frac{1}{T} \sum_{k=T-1}^{T} I(m, n, c, k) .
\]

(7)

In our simulations, we choose \( \Delta = 300 \) and \( T = 2F/3 \) where \( F \) is the number of frames per
second. For the pixel that the background has been known, if

\[
\left( I(m, n, L) - B(m, n, L) \right)^2 + 4 \left( I(m, n, a) - B(m, n, a) \right)^2 \\
+ 4 \left( I(m, n, b) - B(m, n, b) \right)^2 > \Delta,
\]

then we conclude that the pixel is in the foreground. Otherwise, the pixel is in the background.

For the part where the background has not been determined, we first determine the foreground candidate region. We find the minimal and the maximal values of \( m \) and \( n \) that satisfy \( D(m, n, k) > \Delta \) and denote them by \( m_1, m_2, n_1, \) and \( n_2, \) respectively. Then, \( m \in [m_1, m_2] \) and \( n \in [n_1, n_2] \) is the foreground candidate region. Then, we perform superpixel segmentation for the foreground candidate region. A superpixel is a group of pixels that have similar colors and locations (Fulkerson et al., 2009 and Achanta et al., 2012). There are many types of superpixels. We choose the SLIC superpixel proposed in (Achanta et al., 2012) because its computation complexity is less. Then, we perform superpixel merging. That is, the adjacent superpixels with similar color are combined.

After decomposing the foreground candidate region into several segments by superpixels, then we determine the boundary of each pair of adjacent segments. If segment \( i \) is adjacent to segment \( j \) and \((e_s, f_s) (s = 1, 2, \ldots, S)\) are the pixels at the boundary of segments \( i \) and \( j \). If

\[ D_\Delta(m, n, k) = 1 \text{ when } D(m, n, k) > \Delta \]

and \( D_\Delta(m, n, k) = 0 \) otherwise, then we calculate

\[ e_{i,j} = \frac{1}{S} \sum_{s=1}^{S} D_\Delta(e_s, f_s, k), \]

\[ E_{i,j} = 1 \text{ if } s_{i,j} > 1/3 \quad \text{and} \quad E_{i,j} = 0 \quad \text{otherwise.} \]

Then, we determine whether a segment is a foreground one. First, we set the pixels that are not in the foreground candidate region as the background part. If segment \( i \) has been determined as a background segment and \( E_{i,j} = 0 \), then we intend to conclude that segment \( j \) is a background segment. If segment \( i \) has been determined as a background segment and \( E_{i,j} = 1 \), then we intend to conclude that segment \( j \) is a foreground segment. If the segment \( j \) is adjacent to more than two segments, we use the following equation to conclude whether segment \( j \) is a foreground or a background segment:
where $S_j$ is the total boundary length of the segment $j$, $S_{\beta j}$ is the length of the boundary of the segment $\beta$ and the segment $j$, and the segment $\beta$ are the segments that are adjacent to the segment $j$ and has been classified into the background segment. Moreover, $U_j$ is the total number of pixels of the segment $j$ and $Q_j$ is the number of pixels within the segment $j$ that satisfy $D(m, n, k) > \Delta$. If

$$\text{score}_j > 0,$$  \hspace{1cm} (12)

then the segment $j$ is identified as a foreground segment. Otherwise, it is identified as a background segment.

After determining the foreground part of each frame, we perform the opening operation and the closing operation of morphology to refine the foreground detection result. Then, we update the known background part according to (3)-(7) and process the next frame. The process is terminated when all of the frames have been processed.

Note that, when using the proposed algorithm, to determine the foreground part of the $k$th frame, the information of the $l$th frame where $l > k$ is not required. Therefore, the proposed algorithm can be performed in real time.

3. Results

In this section, some simulations are performed to compare the foreground extraction results of the proposed algorithm, the GMM-based algorithm in (Zivkoic, 2004), and the RPCA algorithms in (Lin et al., 2010) and (Zhou et al., 2013).

In Figs. 2, 3, 4, 5, we show the foreground segmentation results. The test data is a video for a man who walked and carried a bag. It has 152 frames and there are 30 frames per second. The original frame is shown in (a). The results of the proposed algorithm is shown in (b). The results of the algorithms in (Zivkoic, 2004), (Lin et al., 2010), and (Zhou et al., 2013) are shown in the subfigures of (c), (d), and (e), respectively. In Figs. 2, 3, 4, and 5, we show the detected foreground of the $12^{th}$, $42^{nd}$, $75^{th}$, and $125^{th}$ frames, respectively. Note that, when using the proposed algorithm, the foreground can be detected very accurately and the shadow part will not be regarded as the moving object. When using the algorithm in (Cucchiara et al., 2003), the foreground can be detected only after the $15^{th}$ frame and the shadow is misjudged as the foreground. When using the method in (Lin et al., 2010), only part of the border of the foreground is detected. When using the method in (Zhou et al., 2013), some background parts (the shadow and the surrounding of the man) are misidentified as the foreground.
The computation time of the proposed algorithm for a 108x192 video with 152 frame is only 0.97 sec. That is, the proposed algorithm not only has good performance for foreground detection but also has less computation time.

Fig. 2 Foreground detection results for the 12th frame using the proposed and other methods.
(a) the 42nd frame

(b) foreground by the proposed algorithm

(c) foreground by (Zivkoic, 2004)  
(d) foreground by (Lin et al., 2010)
Fig. 3 Foreground detection results for the 42nd frame using the proposed and other methods.

(e) foreground by (Zhou et al., 2010)
Fig. 4 Foreground detection results for the 75th frame using the proposed and other methods.
4. Conclusion

A real time and accurate foreground extracting algorithm is proposed. With the proposed techniques of fast scanning, the computation time of the proposed algorithm is very less. Moreover, the techniques of superpixels, the frame difference at the boundary, and the Lab color space are applied to improve the performance of foreground detection. Simulations show that the proposed algorithm can detect the moving object suddenly and is robust to noise and...
shadow.

**Acknowledge**
This work was supported by Qualcomm Technologies Inc.

**Reference**


ICEAI-1016
A Spring-Damping Transformation Method for Solving Cauchy Problems of Nonlinear Parabolic Equations without Initial Data

Chih-Wen Chang¹⁺, Shengwen Wang²
¹Department of Mechanical and Computer-Aided Engineering, Feng Chia University, Taiwan
²Cloud Computing and System Integration Division, National Center for High-Performance Computing, Taiwan
*E-mail address: chihwen.chang8@gmail.com

1. Background/ Objectives and Goals
In this study, the Cauchy inverse problem of generalized Burgers-Huxley and Burgers-Fisher equations will be investigated numerically. Even lots of researchers have used many approaches to overcome these forward problems of two equations. Generally speaking, the exact solutions of nonlinear evolution equations are difficult to reveal and often impossible to obtain the exact solutions. Thus, these numerical methods are recommended to make keen observation of the nonlinear models. The traditional methods are available for the numerical solution of the differential equations by using the finite difference methods (FDM), finite element method (FEM) and finite volume method (FVM) and so forth. The FDM has lost its popularity because of stability problems and less accuracy. The FEM and FVM need more mesh generations in higher dimensions are tough tasks in the computational process; however, an effective numerical scheme to solve these inverse problems is still not available. First, we transform these two equations into two new ones, including a spring term and a damping term, respectively, which can raise the accuracy of numerical solution. Then, we apply a semi-discretization of finite difference method and a two-stage group-preserving algorithm to reveal the unknown physical quantity. Since this new computational approach is on the basis of a concrete theoretical foundation, it can result in a deeper understanding of nonlinear inverse problems (e.g., shock wave formulation, boundary layer behavior, traffic flow and sound waves in viscous medium). The major purpose of this study is to apply the property of spring-damping transformation and Lie group in developing an effective numerical approach.

2. Methods
We have made a variable transformation because the transformation does not alter the type of the governing equation and is not a perturbation of the original issue, and the parameter is not a regularization parameter in the concept of Tikhonov. Therefore, we cannot directly utilize the concept of those for the Tikhonov regularization schemes to choose the regularization parameter, which is closely related to the noise being imposed on the known input data. Because the transformation is completely mathematical, it does not change the type of this inverse problem; nevertheless, the introduction of the parameter can increase the accuracy of
numerical solutions. We cope with these two ill-posed problems by utilizing the regularization through a two-stage group-preserving scheme (GPS). The numerical algorithm of lines is simple that for a given system of partial differential equations, and we discretize all but one of the independent variables. The semi-discrete process produces a coupled system of ordinary differential equations which are then being numerically integrated. Besides, we adopt the numerical method of lines to discretize the time coordinate $t$.

3. **Expected Results/ Conclusion/ Contribution**

In this research, we first transformed the nonlinear parabolic equation by employing a spring-damping transform method (SDTM) via a parameter. Then, by using a two-stage GPS, we can retrieve the heat flux and temperature very well for the Cauchy problem of nonlinear parabolic equation without initial data. Actually, the parameter is not a regularization parameter and it plays both a damping and a spring constant, which can slightly stabilize the governing equations and increase the accuracy of the numerical results. Several numerical examples of the Cauchy problem of nonlinear parabolic equation without initial data were straightened out, which displayed that the new numerical integration approaches were applicable to the Cauchy problem of nonlinear parabolic equation without initial data, even for the very seriously ill-posed ones. Under the two left-end boundary conditions with a quite large noise and a large time span, the two-stage GPS and the SDTM were also robust enough to recover right-end temperatures and initial temperatures and heat fluxes. The numerical errors of proposed algorithm with large noise are in the order of $O(10^{-5}) - O(10^{-18})$.

Keywords: Cauchy problem, strongly ill-posed problem, nonlinear parabolic equations, without initial data, group preserving scheme (GPS)
Environmental Sciences/ Energy Engineering

Thursday, May 12, 2016 09:30-10:30  Room 1008

ICCBES-1068
Solar Photocatalytic Degradation of Azo-Dye Wastewater with a Hybrid of TiO$_2$ and P3HT@TiO$_2$ Nanocatalysts
Wen-Shiuh Kuo | National United University
Ya-Ting Ji | National United University

ICCBES-1095
Tolerance of Different Green Microalgae to Toxicity of Estradiol (E2) and Ethinylestradiol (EE2)
Nora Fung-Yee Tam | City University of Hong Kong
Ping Wang | City University of Hong Kong
Dan Deng | City University of Hong Kong
Yuk-shan Wong | Open University of Hong Kong

ICCBES-1148
Heat Island Analysis for the Protected Horticulture Complex in the Summer Season
Donghyeon Kang | National Academy of Agricultural Science
Minjae Kong | National Academy of Agricultural Science
Siyoung Lee | National Academy of Agricultural Science
Jongku Kim | National Academy of Agricultural Science
Sungwook Yun | National Academy of Agricultural Science
Jinkwan Son | National Academy of Agricultural Science

ICCBES-1177
An Observation on the Effects of Cationic Gemini Surfactants [Gemini (12-4-12), Gemini (12-2-12)] on the Development of Theseeds of (Lentil)Lens CulinarisMedik
Feruzan Dane | Trakya University
Hazal Sezginer | Trakya University
Halide Akbaş | Trakya University
Mesut Boz | Trakya University
ICCBES-1183
Isolation of Phycobiliproteins from Rhodomonas Salina
Chanoknard Karnjanapak | Chulalongkorn University
Sutaporn Bunyajetpong | Chulalongkorn University
Thaithawon Lirdwitayaprasit | Chulalongkorn University
Gerald Plumley | Chulalongkorn University

ICCBES-1188
Change Analysis of Plant Diversity in Protected Horticulture Complex of Agricultural Ecosystems in South Korea
Jinkwan Son | National Academy of Agricultural Science
Siyoung Lee | National Academy of Agricultural Science
Donghyeon Kang | National Academy of Agricultural Science
Minjae Kong | National Academy of Agricultural Science
Minjung Park | National Academy of Agricultural Science
Sunguk Yoon | National Academy of Agricultural Science

ICCBES-1189
Test on Characteristics of Internal Environment Special Variability in Plastic Greenhouse Using Computational Fluid Dynamics Simulation
Jae Su Lee | National Academy of Agricultural Science
Sang Cheol Kim | National Academy of Agricultural Science
Gook Hwan Kim | National Academy of Agricultural Science
Young Gi Hong | National Academy of Agricultural Science

ICCBES-1220
Isolation and Characterization of Bacterium that Promotes the Antibiotic Production in the Presence of Rice Husk Biochar
Shohei Ebe | Kindai University
Tatsuya Ohike | Kindai University
Masahiro Okanami | Kindai University
Takashi Ano | Kindai University

ICCBES-1228
Jin kyung Kwon | Protected Horticulture Research Institute
Jong gil Jeon | Protected Horticulture Research Institute
Hyung Gweon Kim | Protected Horticulture Research Institute
**ICCBES-1240**


Pi-Guey Su | *Chinese Culture University*
Meng-Shian Tsai | *National Taiwan Normal University*
Chia-Jung Lu | *National Taiwan Normal University*

**ICCBES-1255**

**Evaluation of Greenhouse Gases Emissions from Wastewater Treatment Plant in Taiwan**

Jen Po Hung | *National Taipei University*
Ying Chu Chen | *National Taipei University*

**ICCBES-1259**

**Impacts of Travel Motivation and Experience of Tourists on Word-of-Mouth and Revisit Intention of Lighthouse**

Chen Chieh Sheng | *National Taipei University*
Ying Chu Chen | *National Taipei University*

**ICCBES-1287**

**Carbon Capture by Dissolution of Carbonate Minerals**

Ming-Hui Chang | *Industrial Technology Research Institute*
Pei-Shan Hsieh | *Industrial Technology Research Institute*
Kuo-Wei Huang | *Industrial Technology Research Institute*
Chuan-Wei Chung | *Industrial Technology Research Institute*
Yi-Tun Hsu | *Ming-Chi University of Technology*
Chi-Wen Liao | *Industrial Technology Research Institute*
Heng-Wen Hsu | *Industrial Technology Research Institute*

**ICCBES-1333**

**Review of Ecological Engineering Solutions for Rural Non-Point Source Water Pollution Control in Hubei Province, China**

Min Wu | *Changjiang River Scientific Research Institute*

**ICCBES-1334**

**Mechanisms of the Phytoremediation of Pentachlorophenol Contaminated Sediment by Aquatic Macrophytes**

Liangyuan Zhao | *Yangtze River Scientific Research Institute*
ICCBES-1297
Shewanella Induced Nanostructured Crystal Materials
Pao-hung Lin | National Taiwan University of Science and technology
Ying-Tang Huang | National Kaohsiung Marine University
Jung-Te Hsieh | National Taiwan University of Science and technology

ICEAI-1103
Research of Ventilation Effects of Atrium Forms in Vernacular Fujian Tulou
Ying-Ming Su | National Taipei University of Technology
Shu-Chen Huang | National Taipei University of Technology

ICEAI-838
Recent Viscosity Data for Al₂O₃ Nanofluids – Behaviour and Stability under Heating Effects
Cong Tam Nguyen | Université de Moncton
Marc-André Hachey | Université de Sherbrooke

ICEAI-989
On the Coupling between the Dynamic Viscosity and Thermal Conductivity for Al₂O₃ Nanofluids – Some Insights onto the Characterisation of Nanofluid Thermal Properties
Cong Tam Nguyen | Université de Moncton
Marc-André Hachey | Université de Sherbrooke
Nicolas Galanis | Université de Sherbrooke
Catalin Viorel Popa | Université de Reims

ICEAI-1164
Study for the Solar Thermal Collector due to Falling Dust by Numerical Simulation and Experiment
Jiann Lin Chen | I-Shou University
Peng Siang Hong | I-Shou University

ICEAI-1182
An Application of Maximum Likelihood Estimation in Radiation Portal Monitors
Jiyon Lee | Korea Institute of Nuclear Safety
Byoung-Jik Kim | Korea Institute of Nuclear Safety
ICEAI-1218
Thermally Developing Convection Heat Transfer of a Microencapsulated Phase Change Material Suspension through a Partially Heated Circular Tube – An Experimental and Numerical Study
C. J. Ho | National Cheng Kung University
J. B. Huang | National Cheng Kung University
C. P. Chen | National Cheng Kung University

ICEAI-1225
The Investigation of Charge Transport Behavior of Ionic Liquid/PVDF-HFP Electrolyte with Propylene Carbonate Solvent
Jun-Hong Lin | National Kaohsiung University of Applied Sciences
Zhao-Cheng Chen | National Kaohsiung University of Applied Sciences
Bo-Wen Shi | National Kaohsiung University of Applied Sciences

ICEAI-1232
Using AHU Outdoor Air Demand Control and VAV for Energy-Saving and Indoor Air Quality
Yu-Lieh Wu | National Chin-Yi University of Technology
Jian-An Chen | National Chin-Yi University of Technology
Kun-Hua Lyu | National Chin-Yi University of Technology
Yu-Chien Lin | National Chin-Yi University of Technology
Jun-Tsuo Chiu | National Chin-Yi University of Technology
ICCBES-1068
Solar Photocatalytic Degradation of Azo-Dye Wastewater with a Hybrid of TiO$_2$ and P3HT@TiO$_2$ Nanocatalysts

Wen-Shiuh Kuo*
Department of Safety, Health, and Environmental Engineering, National United University, Taiwan
E-mail address: wsk@nuu.edu.tw

Ya-Ting Ji
Department of Safety, Health, and Environmental Engineering, National United University, Taiwan
E-mail address: M0213008@smail.nuu.edu.tw

1. Background/Objectives and Goals
TiO$_2$ photocatalysis using solar irradiation has been used as an economically viable process and has attracted great interest in recent years. However, due to the intrinsic structure characteristics and broad band gap (3.2 eV for anatase) of TiO$_2$, TiO$_2$ can only be excited by ultraviolet light (<387nm) (which is less than 5% in solar light) to produce photoinduced hole–electron pairs and the inherent recombination of photo-generated electron-hole pairs, resulting in a low utilization of solar energy and photocatalytic activity. To eliminate these drawbacks of TiO$_2$, dye-sensitized photocatalytic materials exhibit high efficiency in degradation of organic pollutants and utilization of visible light has been hybridized with TiO$_2$. Poly(3-hexylthiophene)(P3HT) is an organic semiconductor with the property of dye sensitizer. It has high charge carrier mobility, dissolubility and processability, long-term stability and a broad and strong absorption invisible region (with bandgap of 1.9–2.0 eV). In this study, shell-core P3HT@TiO$_2$ nanoparticles were prepared and used to enhance the photocatalytic activity of TiO$_2$ in degrading methyl orange (MeO) azo-dye wastewater under solar irradiation. The hybrid effect was then investigated using a response surface methodology (RSM) experimental design.

2. Methods
Methyl orange (MeO) (C$_{14}$H$_{14}$N$_3$NaO$_3$S, $\lambda_{\text{max}}$: 464 nm, C.I. No.: 13025) was purchased from Sigma-Aldrich Co., USA and used without further purification. An initial MeO concentration of 50 mg/L was prepared for all experimental runs. TiO$_2$ powder - P25 (mainly anatase form, with a mean particle size of 30 nm and a BET surface area of 50±15 m$^2$/g) from Degussa Co. (Frankfurt, Germany) were used in this study. P3HT (MW: 40,000 - 80,000) with a purity of 99.9% were purchased from Uni-Ward Co., Taiwan and used without further purification. The shell-core P3HT@TiO$_2$ composite particles were synthesized by a physical deposition method.
using tetrahydrofuran (THF) as a solvent of P3HT in a TiO$_2$/THF suspension. The composites are labeled as P3HT(X%)/TiO$_2$, where X corresponds to the P3HT content in the composites. The P-25 TiO$_2$ and shell-core P3HT@TiO$_2$ composites were characterized by a JEOL JSM-6700F Scanning Electron Microscope (SEM)/ X-ray Energy Dispersive Spectrometer (EDS), a Rigaku TTRAX III X-ray diffraction (XRD), a Hitachi U-3900 UV/VIS Diffuse Reflectance Spectroscopy (UV/VIS DRS), and a Microtrac S3500 Laser diffraction particle size analyzer. A Box-Behnken 3 factors * 3 levels experimental design with three replicates at center point according to the methodology of response surface was applied to investigate the hybrid effect and the influence of three factors (namely, photocatalyst dosage, g/L; P3HT@TiO$_2$, %; P3HT@TiO$_2$/(P3HT@TiO$_2$+TiO$_2$), %) for MeO degradation and mineralization efficiency.

3. Expected Results/ Conclusion/ Contribution

According to the UV-VIS diffuse reflectance spectra of this study, TiO$_2$ powder could only absorb UV light with wavelength lower than 390 nm while the pure P3HT powder can absorb UV and VIS light with wavelength lower than 650 nm because of its narrow band gap (1.9 – 2.0 eV). P3HT@TiO$_2$ composites can absorb both UV light (200 – 400 nm) and visible light (400 – 700 nm). This may be due to the characteristic absorption of TiO$_2$ and the P3HT absorption band in the UV light region. With an increase of P3HT content, the absorbance for P3HT@TiO$_2$ composites increases in the visible light region. In this study, P3HT(1%)@TiO$_2$ composites could increase the absorption up to 75% in the band of visible light. Powder XRD analysis confirmed the presence of TiO$_2$ mainly with anatase phase in the P3HT@TiO$_2$ composites. Also, the representative peak (5.3°) of P3HT appeared in XRD diagram, illustrating the existence of P3HT in P3HT@TiO$_2$ composite. In addition, the SEM images showed that P3HT polymers were homogeneously dispersed onto the surface of TiO$_2$. The particle size of TiO$_2$ and P3HT@TiO$_2$ were estimated to be in the same range. Moreover, it was found that the optimized combination based on the application of a 3*3 RSM regression model were established as a photocatalyst dosage of 1.5 g/L, a P3HT of 0.5% in P3HT@TiO$_2$ and a 25% P3HT@TiO$_2$ of total photocatalyst dosage for a MeO degradation efficiency of 95%. Under the optimized conditions, the TOC mineralization efficiency of MeO wastewater was 63.3%, which increased 30.1% as compared to that of pure TiO$_2$ process for a reaction time of 120 min. Consequently, the hybrid of TiO$_2$ and P3HT@TiO$_2$ could effectively enhance the solar photoactivity of TiO$_2$.

Keywords: solar photocatalytic degradation, methyl orange, P3HT@TiO$_2$, response surface methodology
Tolerance of Different Green Microalgae to Toxicity of Estradiol (E2) and Ethinylestradiol (EE2)

Nora Fung-Yee Tam, Ping Wang, Dan Dang
Department of Biology and Chemistry, City University of Hong Kong, China
E-mail address: bhntam@cityu.edu.hk

Yuk-shan Wong
School of Science and Technology, Open University of Hong Kong, China
E-mail address: yswong@ouhk.edu.hk

1. Background/ Objectives and Goals
Estrogens, a group of steroid hormones, are serious environmental pollutants due to their persistence and endocrine-disrupting toxicity. Natural and synthetic estrogens, such as 17β-estradiol (E2) and 17α-ethinylestradiol (EE2), respectively, have been found in wastewater. The ability of microorganisms to remove estrogen has been reported but the species must be able to tolerate its toxicity. The present study aims to investigate the tolerance of six microalgal species and compare any difference between commercial species and local isolates.

2. Methods
The growth responses of three commercially available species and three local isolates to estrogens were tested. The three commercial species were Scenedesmus quadricauda (SQ), Selenastrum capricornutum (SC) and Chlorella vulgaris (CV), the first species was purchased from Culture Collection of Algae at the University of Texas at Austin (UTEX) and the last two were from Carolina Biological Supply Company, USA. The three local species, namely Chlamydomonas sp. (WW), Chlorella sp. (2f5aia) and Chlorella sp. (1uoai), were isolated from polluted water in Hong Kong. All microalgal species were cultured in either Bristol (BM) or SE medium with continuous supply of filtered air, and illuminated with a diurnal cycle of 16 hours light and eight hours dark. After reaching the exponential growth phase, microalgal cells were harvested and the washed cell pellets were re-suspended.

For each microalgal species, a total of 15 sterilized Erlenmeyer flasks (100 mL), each containing 20 mL culture medium and had the same initial dry weight of microalgal cells (70 mg L⁻¹), were prepared. The flasks were divided into five groups, each in triplicate, with the addition of different concentrations of mixed estrogens (equal amount of E2 and EE2), that is, 0 (control), 1, 4, 10 and 20 mg L⁻¹. At Days 1, 2, 4 and 7, cell growth, in terms of the changes in cell number, cell volume, auto-fluorescence, cell division and cell viability, was determined. The cell number was counted with a Nuebauer counting chamber under a Zeiss Axioskop.
microscope (Zeiss, USA) and the cell volume was determined with a particle counter (Beckman Coulter Multisizer 3, USA). The other parameters were analyzed by the BD FACS Calibur Flow Cytometer (Becton Dickinson Instruments, USA), equipped with an argon ion (488 nm) laser light-scatter detectors and three fluorescence detectors.

3. Results/ Conclusion/ Contribution

Results showed that the sensitivity of the microalgae to estrogen toxicity was highly dose-, incubation time-, and species-dependent. The increase in cell numbers of SQ at the end of the 7-day incubation reduced significantly with increasing E2 and EE2 concentrations. Two-way multivariate analysis of variance (MANOVA) results further showed that the changes in the cell numbers of SQ were significant with time. Accompanied with the changes in cell number, other growth responses, including increases in cell volume and decreases in cell division, were observed with increasing E2 and EE2 concentrations. The other five species presented different degrees of adaptations to E2 and EE2. For species of 2f5aia and CV, E2 and EE2 had an adverse effect on the increase in cell number, but such response correlated poorly with concentrations. For species of SC and WW, E2 and EE2 had no effect on cell number at 1 mg L\(^{-1}\) but became stimulatory at 4-20 mg L\(^{-1}\). No significant differences were found in the cell numbers of 1uoai when exposed to different E2 and EE2 concentrations (Two-way MANOVA, \(P = 0.349\)). In addition to cell numbers, other growth parameters, including reduction in chlorophyll a fluorescence, in the five species also showed significant changes in response to estrogen toxicity. The percentages of inhibition to E2 and EE2 at 96 hours of exposure demonstrated that the sensitivity of the six microalgal species followed the order of SQ > CV = WW = 2f5aia ≥ 1uoai = SC, suggesting that SQ was the most sensitive species to E2 and EE2 and SC was the most tolerant one.

In conclusion, the present study demonstrates that the tolerance of microalgae to mixed estrogens (E2 and EE2 at equal amounts) did not seem to be related to the origin of the species, as there was no significant difference in growth responses between commercial species and local isolates of the same genus. Even for the same genus such as Chlorella, the three species showed different responses to estrogen toxicity. The smallest EC\(_{50}\) value recorded in the most sensitive species was higher than the concentrations of estrogens in the environment, indicating that the contamination of estrogens in wastewater and surface water should not cause any harmful effects to microalgae. The most resistant species identified in the present study could be a potential candidate for the removal of wastewater-borne estrogens.

Keywords: estrogen, wastewater, microalgae, toxicity
Heat Island Analysis for the Protected Horticulture Complex in the Summer Season

Donghyeon Kang  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: kang6906@korea.kr

Minjae Kong  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: alswogud@dankook.ac.kr

Siyoung Lee  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: leesy42@korea.kr

Jongku Kim  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: kimjk1960@korea.kr

Sungwook Yun  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: wook@korea.kr

Jinkwan Son  
National Academy of Agricultural Science, RDA, South Korea  
E-mail address: son007005@korea.kr

1. Background/Objectives and Goals
The world is facing various environmental problems. Therefore, it is important to preserve the natural ecosystem along with agriculture and farming villages. Recently, however, the agricultural landscape is also facing various problems. Therefore, a study on the bio-diversity, preservation, and improvement of the ecosystem service is needed. Among the agricultural landscapes, the protected horticulture complex can be evaluated as a facility where the operation of the ecosystem service is hindered. This study investigates the issue of temperature rise due to the protected horticulture complex. The results are used to find the size, arrangement, and ways to reduce the heat island of the protected horticulture complex. This could be developed into a building model for an environmental-friendly and ecologically protected horticulture complex.
2. Methods

Eight sites across four regions were selected for this study. In case of Gumi (GM) and Gimje (GJ), paddies (GMp, GJp) and glass greenhouses (GMg, GJg) were compared. In case of Buyeo (BY) and Jinju (JJ), paddies (BYp, JJp) and multi-span plastic houses (BYm, JJm) were compared. The temperature distribution was investigated in 2015 during maximum temperature variation in the summer season. At each site, 10 temperature observations were taken for a day. The results were obtained from the analysis of the distribution of the highest temperature based on land use. And it was drawn it through a GIS.

3. Expected Results/Conclusion/Contribution

The distributions of the highest summertime temperatures of paddies, greenhouses, and multi-span plastic houses were investigated. The temperature differences can be compared according to the regions. In Gumi and Gimje regions, paddies and greenhouses were compared. In Gumi, paddy (GMp) recorded 38.28±2.07°C, and greenhouse (GMg) recorded 39.49±1.13°C, with a difference of 1.21°C. In Gimje, paddy (GJp) recorded 34.94±1.57°C, and greenhouse (GJg) recorded 37.03±1.16°C, with a difference of 2.09°C. In case of Buyeo and Jinju regions, paddies and multi-span plastic houses were compared. In Buyeo, paddy (BYp) recorded 33.50±0.90°C, whereas the multi-span plastic house (BYm) recorded 34.44±1.43°C, with a difference of 0.93°C. In Jinju, paddy (JJp) recorded 35.30±0.85°C, and multi-span plastic house (JJm) recorded 38.26±1.14°C, with a difference of 2.96°C. Additional research is needed to identify the causes of the temperature differences. In this study, it was observed that the temperature rises in grasshouses and plastic houses were more than paddies.

Acclimatization is an important function in the ecosystem service of agriculture. It is undesirable for the temperature to rise in the summertime due to protected horticulture. Technological development is needed that can keep the temperature low.

The right arrangement and size to reduce the temperature will be investigated in a future study. A building model for the protected horticulture complex will be developed by utilizing the results.

Acknowledgements

This study was carried out with the support of "Research Program for Agricultural Science & Technology Development (Project No. PJ010957)", NAAS, RDA, Republic of Korea.

Keywords: Air temperature, GIS, Greenhouse, Design, Ecosystem Service
1. Background
Surfactants are amphipathic molecules that lower the surface tension between two liquids or between a liquid and a solid [1]. Gemini or dimeric surfactants are novel surfactants that have become of considerable interest in the academic and industrial arena. These surfactants are used in skin care formulations, antipollution protocols, analytical separations, nanoscale technology [2]. There are many studies about the phytotoxic effects of different concentrations of different surfactants on Onion (Allium cepa) which were done by us [2-5]. However there isn’t any study similar to present study. The effects of surfactants have a marked impact on human health care, bio-technology, environmental protection and agrochemistry. It's important that determine (EC_{50}) concentration, which are close to control values. In addition it must be selected appropriate surfactant, which has minimal toxicity and maximal benefits for each purpose. This is an original research about effects of gemini series. In order to evaluate the effect of alkyl chain length variation (m= 12) on inhibitory effect, we kept the spacer chain length (s=2/4) and head groups the same in two geminis. The aim of this study was to investigate the phytotoxic effects on seed germination and root growth the effects of Gemini“12-4-12” and “12-2-12” surfactant solutions under laboratory conditions using lentil (Lens culinaris Medik. cv. Sultan) as a test material.
2. Methods

In this study, the gemini surfactants of the alkanediyl-a-x-bis(alkyl dimethyl ammonium) dibromide type, referred to as ‘‘12-4-12’’ and ‘‘12-2-12’’ were selected to examine their effects of the seeds of lentil. These dimeric cationic gemini surfactant were synthesized in our laboratory by Mesut Boz. We were evaluated under laboratory conditions using lentil as a test material. Surfactants were prepared at three different surfactant concentrations; 2 g/L, 1 g/L and 0.5 g/L concentrations. The phytotoxic effects were determined on root after 7th days and on germination rates after 2th days. The lentil (Lens culinaris Medik. Cv. Sultan) was used in this study. The selected seeds were sterilized with 75% (v/v) ethanol for 2 min, followed by 2.5% (v/v) sodium hypochlorite for 10 min and washed thoroughly with distilled water. 30 seeds of lentil were planted in each on filter paper in Petri dish for 48 h at 25 ± 2 ºC in dark conditions. The root tips which 0.5 mm and higher were determined as germinated. Then the germinated seed with primary roots (3-5 mm long) were treated for 7 days. Control groups were germinated in distilled water. Experiments were made 3 times. Root lengths were measured using a millimeter ruler starting at the onset of incubation, then after 1st, 2nd, 3rd, 4th, 5th, 6th and 7th days. At the end of the 7th day, the total root lengths were measured. Means of the length of lentil root tips and percent of seed germination were determined. The phytotoxicity results were based on the effective concentration that reduced root growth by 50 % (EC\textsubscript{50}).

3. Results

It was observed that inhibitory effects increased with increasing concentrations of in both Gemini surfactants. As a result of Gemini (12-4-12) and Gemini (12-2-12) observed that the percentages of seed germination were decreased while the concentrations were increased. The phytotoxicity result of Gemini (12-4-12) 50 % (EC\textsubscript{50}) is 1 g / L and Gemini (12-2-12) 2g/L was determined. Gemini (12-4-12) is more toxic than Gemini (12-2-12).

4. References

[4]. Dane, F., Akbaş, H., Türkoğlu, M., Leventer, S. (2014). Phytotoxic effects of dimeric cationic surfactant Gemini (16-2-16), (16-6-16) and (16-10-16).” IICBE INT’L
conferences (CEBS-2014) Book, 17-18 September 2014, P: 72-75, Kuala Lumpur, MALAYSIA.


Keywords: Cationic Surfactants, Lens culinaris, Phytotoxic effect, Gemini(12-4-12), Gemini(12-2-12)
Isolation of Phycobiliproteins from Rhodomonas salina

Karnjanapak, C.\textsuperscript{a}, Bunyajetpong, S.\textsuperscript{b,*}, Lirdwitayaprasit, T.\textsuperscript{c}, and Plumley, F.G.\textsuperscript{d}

Department of Marine Science, Chulalongkorn University, Thailand

\textsuperscript{a} E-mail address: chanoknard_ck@hotmail.com
\textsuperscript{b} E-mail address: sutaporn.b@chula.ac.th
\textsuperscript{c} E-mail address: lthaitha@chula.ac.th
\textsuperscript{d} E-mail address: gerryplumley@yahoo.com

Abstract

\textit{Rhodomonas salina} accumulates PE545, a well-characterized phycobiliprotein. PE545 is water soluble due to the hydrophilic nature of the apoproteins. PE545 should be relatively easy to isolate from this alga based on procedures that disrupt cellular integrity (e.g., repeated freeze-thaw cycles, frequently including sonication). Results shown here indicate that PE545 is easily extracted from cells grown in f/2 media but not from those grown in Daigo IMK media. To facilitate PE545 extraction from cells grown in the Daigo IMK, three buffers at nine pH values were tested in combination with three freeze-thaw-sonication cycles (3X-FTS). Several buffer/pH combinations yielded extracts enriched in PE545 with absorption spectra similar to that observed in whole cells; the supernatants were ‘pink’ ($A_{\text{max}}$ at 545-550 nm) and were generally associated with buffers of pH 6 and 7. Some buffer/pH combinations yielded extracts enriched in PE545 but also enriched in chlorophylls and carotenoids; the supernatants were ‘red’ in color and tended to prevail at pH values $\geq$ 6. At the two lowest pH values the peaks were red shifted by 5-10 nm and were ‘purple’ in color.

Co-extraction of PE545 and chlorophyll/carotenoids was problematic; hence the latter pigments were extracted in 90% acetone. Four buffers were tested at nine pH values to identify conditions that extracted PE545 from the acetone pellets. At pH values of 6 – 7, regardless of the buffer, the PE545-enriched supernatants showed pronounced peaks in the 545 – 550 nm range. In contrast, the two lowest pH buffers yielded red shifted peaks (556 – 564 nm); at pH 8 the peaks tended to shift toward the blue by a few nm, while at pH 9 the peaks were blue shifted (518 – 536 nm).

Buffers at pH 6 and 7 tended to provide greater extraction efficiencies of PE545 than lower or high pH values, but results varied broadly, depending on the buffer. Once extracted, PE545 exhibited strong pH-dependent stability, being surprisingly robust at very low pH as well as at pH values centered on pH 6. Pigment degradation was most pronounced at pH 9, regardless of the buffer.

None of the tested conditions allowed complete PE545 extraction, even if the 3X-FTS was
repeated several times. Treatment of samples with SDS, but not urea, tended to result in complete extraction with several buffer/pH combinations. The use of acetone extraction followed by SDS-containing buffers is recommended for complete extraction.

**Keywords**: phycobilin, pigment extraction, photosynthesis

1. **Background/ Objectives and Goals**

Phycobilins are major accessory photosynthetic pigments found in Cyanophyta, Cryptophyta and Rhodophyta (Jeffrey and Mantoura 1997), which are important for primary production in freshwater and marine ecosystems. Phycobilins are the chromophore of pigment-protein complexes known as phycobiliproteins; the phycobilins are covalently bound to cysteine of apoproteins by thioether bonds (Zhao et al. 2011). The optical absorption of phycobiliproteins is in the range of 500 – 650 nm, wavelengths that are poorly absorbed by chlorophylls and carotenoids (Zhao et al. 2011). For example, the absorption wavelengths of blue phycocyanins is ~ 600 nm, the blue-green allophycocyanins is ~ 650 nm, and the red phycoerythrins is ~ 550 nm (Zhao et al. 2011).

The individual phycobilins have broad (and diverse) absorption spectra *in vivo*, as compared to *in vitro*, in different algae; these differences are related to differences in ‘local environments’, including pigment-protein interactions, ‘package effects’, and a number of other considerations (Morel and Bricaud 1981; Bricaud and Stramski 1990). During isolation, phycobiliproteins frequently undergo changes in conformation such that the spectral properties of the phycobilins resemble those of the free pigment rather than those of the fully assembled *in vivo* chromophores (Glazer 1982). These spectral changes can be easily monitored by absorption spectroscopy and are frequently used to assess the status of purified/isolated phycobiliproteins.

Quantification methods of phycobilins are important because these pigments provide insights into important ecological questions (e.g., oceanic rate processes, including those associated with remote sensing data) and are useful biomarkers for environmental issues (e.g., identifying harmful algal blooms and/or problems in aquaculture and eutrophication) (Jeffrey and Mantoura 1997; Paerl and Otten 2013; Lawrenz et al. 2011; Zimba 2012).

The most serious limitation for quantification of phycobilins relates to pigment extraction; these covalently linked pigment-protein complexes, unlike the pigment-associated (but not covalently attached) chlorophylls and carotenoids, are not extracted with nonpolar solvent (e.g., acetone or methanol) (Wright et al. 1997). Extraction of phycobiliproteins from some algae, notably cryptophytes, may be relatively straightforward, requiring aqueous buffers with neutral (to slightly acidic) pH values combined with freeze-thaw (and/or sonication) for cell disruption (Lawrenz et al. 2011). Phycobiliprotein extraction from most algae is more difficult.
Different investigators have employed a variety of methods for extraction, including chemical and/or enzymatic digestion, grinding with and without glass splinters, and/or addition of detergents (Stewart and Farmer 1984; Wedemager et al. 1991; Wedemager et al. 1992; Abable et al. 1998; Viskari and Colyer 2003; Lawrenz et al. 2011; Pandey et al. 2011; Sudhakar et al. 2015).

The phycobiliprotein complex of *Rhodomonas salina*, referred to as PE545, is arguably the most well characterized phycobiliprotein of cryptophytes (MacColl et al. 1998; Wilk et al. 1999; Doust et al. 2004). PE545 contains four apoproteins, $\alpha_1$, $\alpha_2$ plus two $\beta$ subunits. These apoproteins are arranged into a complex known as a dimer of $\alpha\beta$ monomers. Three PEBs (phycoerythrobilin) are covalently attached to each $\beta$ subunit; a single DBV (15,16-dihyrobiliverdin) is covalently attached to each $\alpha$ subunit. In total, PE545 dimers contain four apoproteins and eight phycobilins.

In this study, initial work with *Rhodomonas salina*, grown in f/2 medium, confirmed that PE545 was relatively easy to extract. In contrast, when grown in Daigo IMK medium, PE545 extraction was intractable unless more harsh conditions, including SDS, were included. The main purpose of the work reported here was to develop a suitable technique for rapid method and efficient extraction of PE545 in hopes that these techniques would be more broadly applicable to a large number of algae.

2. Methods

*Rhodomonas salina* was kindly provided by Saskia Ohse (Alfred Wegener Institute, Helgoland, Germany). Cells were cultured with either f/2 or Daigo IMK medium at 24 °C under a photon flux of 41 µmol m$^{-2}$ sec$^{-1}$ with light:dark cycles of 12:12 hr.

Cell density was determined with a Neubauer Improved Brightline hemocytometer (0.0025 mm$^2$). Triplicate 150 ml cultures were inoculated and followed over time; triplicate 1.0 ml aliquots were taken at each time point from each culture and triplicate 10 µl subsamples were counted from each aliquot.

For biochemical analyses, 150-200 ml of cells was transferred to 1200 ml in 2 L flasks. Replicate 35-50 ml samples of culture (8-10 days old; ~1.1 - 1.8 X 10$^7$ cells) were harvested by centrifugation (3,500 g 10 min); the resuspended pellets were transferred to microcentrifuge tubes and collected at 10,000 rpm for 5 min. Cell pellets were stored at -40 °C.

Phycobiliprotein extraction was expedited by three freeze–thaw–sonicate cycles (3X–FTS). Potassium phosphate (KP), sodium phosphate (NaP), Tris-HCl (TB), or acetate (AB) buffers, all at 0.1M with pH values from 1 – 9, were tested. Cell debris was removed by
centrifugation (10,000 rpm for 5 min). Supernatant absorption spectra were recorded on an Analytikjena SPECORD 200 PLUS; spectra were normalized at OD$_{750}$ before plotting. The pellets, frequently enriched in pigments, were processed as described below. In some cases, 90% acetone was used to extract non-polar pigment before extraction of phycobiliproteins in KP, NaP, TB, or AB.

To quantitate phycobiliprotein extraction efficiencies, cell pellets from the 3X-FTS procedure were resuspended in fresh buffer and the 3X-FTS process repeated; SDS was added during the final extraction cycle.

Phycobiliprotein stability was evaluated using the supernatants from 3X-FTS; supernatants were transferred to fresh tubes following centrifugation to eliminate pigments in the cell pellet from interfering with the analyses. Samples were stored for various intervals at either -20 °C or 4 °C in darkness before spectroscopic analysis.

3. Results

3.1. Growth Profiles in Different Media

*Rhodomonas salina* cell density profiles when grown in f/2 and Daigo IMK were similar (Figure 1). Cells in f/2 had a slightly longer lag phase; the small cell density differences during station phase were not significantly different and were similar in both media when cells were harvested (days 8-10). Phycobiliprotein extraction with very high efficiencies could be accomplished from cells grown in f/2 with simple freeze-thaw-sonicate treatments; this was not the case for cells grown in Daigo IMK; the following results are from cells grown in Daigo IMK.

![Figure 1. Cell density profiles of *R. salina* in f/2 and Daigo IMK media.](image-url)
3.2. Extraction of PE545 in Different Buffers/pH

The solubility and properties of biliproteins depend upon the particular biliprotein, its concentration, and the pH and ionic strength of the buffers used for purification (Glazer 1982). KP and/or NaP buffers are frequently used for isolation of phycobiliproteins. Here, three buffers (KP, TB, AB) at nine pH values were tested for extraction of phycobiliproteins following 3X-FTS (Figure 2).

AB buffer at low pH was generally ineffective at solubilization of PE545 while considerable pigment was recovered at pH 5 – 9 (Figure 2A). For TB, higher extraction was noted at pH 3 – 8. In KP, pH 4 – 8 was effective. Some buffer/pH combinations yielded extracts enriched in phycobiliproteins with absorption spectra similar to that observed in whole cells; the supernatants were ‘pink’ (A_max at 545-550 nm.) and were generally associated with buffers of pH 6 and 7 (e.g., AB, TB and KP at pH 6; Figure 2A and B).

Several buffer/pH combinations yielded extracts enriched in PE545 but also enriched in chlorophylls and carotenoids (note the peaks at ~440 ~500 and ~670; Figure 2A). These supernatants were ‘red’ in color and tended to prevail at pH values ≥ 6 (Figure 2B). At the two lowest pH values the peaks were red shifted by 5-10 nm and were ‘purple’ in color (e.g., TB pH 1 – 2; Figure 2A and B). Very little PE545 was detected at pH 9 in TB and KP and the seemingly high absorption of PE545 in AB at pH 9 is likely enhanced by Chl and carotenoids (Figure 2A).

None of the buffer/pH combinations were completely efficient at solubilization of PE545 from these cells. More drastic extraction protocols (e.g., elevated temperatures, longer sonication times, addition of β-mercaptoethanol and/or SDS) were attempted. Success was limited, frequently either PE545 was degraded and/or enhanced recovery of Chl and carotenoids was observed in the aqueous phase; these preliminary results also suggested that Na salts were preferable to K salts, hence NP was subsequently tested along with KP (results not shown). A different approach was required.
Figure 2. Absorption spectra of PE545-containing cell extracts prepared in one of three buffers at nine pH values (A), along with color photographs of the extracts and the cell pellets/debris following extraction (B).

A) PE545-containing extracts in AB (left column), TB (center column) and KP (right column) buffers at pH 1-3 (top row), pH 5-6 (middle row) or pH 7-9 (bottom row).

B) Color photographs of AB, TB and KP (left to right, respectively) at pH 1 – 9 (left to right, respectively), for each buffer.
3.3. Extraction of PE545 from Cells Pre-extracted with Acetone

Co-extraction of phycobiliproteins and chlorophyll/carotenoids was problematic, especially at pH 6 and above (Figure 2A); hence the later pigments were extracted in 90% acetone. The absorption profile of whole cells (in Daigo IMK media), cell pellets resuspended in KP buffer at pH 6, solubilized PE545, and the acetone extract are shown in Figure 3A. The absorption spectra are difficult to normalize, especially for the whole cells in media and the resuspended cell pellets due to the well-known pigment ‘package effect’ as well as scattering from cell walls and other cellular debris (Morel and Bricaud 1981; Bricaud and Stramski 1990). Despite these limitations, the spectra (Figure 3A) are generally consistent with published spectra of *Rhodomonas* spp. Importantly, the isolated PE545 retains the expected absorption spectra with peaks near 545 nm and a prominent shoulder at 567 nm, associated with phycoerythrin and DBV, respectively. Deconvolution of the PE545 absorption spectra, following the guidelines by Billo (2011) and using the expected position and lineshapes of the eight pigments in PE545 (Dourst et al. 2004), yielded a model with good fit to the observed data for PE545 isolated in TB buffer at pH 6 (Figure 3B); similar good model fits were observed in other buffers/pH combinations that yielded the expected ‘pink’ color associated with PE545 (not shown); modeled peaks were generally at, or near, 506, 521, 535, 553, 565 and 572 nm. These results confirm that extraction of cells with 90% acetone prior to extraction in AB, TB and KP do not meaningfully alter the spectral properties of PE545.
Four buffers were tested at nine pH values to identify conditions that facilitated phycobiliprotein extraction from the acetone pellets (Figure 4). As observed previously (with non-acetone-extracted cells; Figure 2), AB at low pH was not effective, while AB at pH 5 – 8 (and somewhat at pH 9) was more effective at solubilization of PE545. TB at pH 4 -8 solubilized considerable PE545. Both KP and NaP were ineffective at pH 1-4, with NaP showing greater extraction than KP at pH 5, 6 and 7, while KP was more effective at pH 8 than NaP (Figure 4A). The results indicated that at pH values of 6 and 7, regardless of the buffer, the PE545-enriched supernatants showed pronounced peaks in the 445-450 nm range. In contrast, the two lowest pH buffers yielded red shifted peaks (556-564 nm); at pH 8 the peaks tended to shift toward the blue by a few nm, while at pH 9 the peaks were very blue shifted (518-536 nm; Figure 4A). Buffers at pH values of 6 or 7 tended to produce peaks with the greatest absorption, due to a combination of high extraction efficiencies and/or stability of
extracted pigments; peak heights were lower at both pH extremes.

Figure 4. Absorption spectra of PE545-containing cell extracts prepared in one of four buffers at nine pH values, along with color photographs of the extracts and the cell pellets/debris following extraction. Cells were extracted in acetone prior to PE545 extraction with aqueous buffers.

A and B) As described in Figure 2, with addition of Na-phosphate (NaP) in the far right column. The PE545-containing supernatant fractions are referred to in the text as PE545\textsubscript{3X-FTS} and are used for analyses shown in Figures 5 and 6.
The photographs in Figure 4B show pigment-enriched cell pellets in all buffer/pH combinations. In other words, pigment extraction was incomplete under all tested conditions. To determine how much PE545 remained in the pellets, extraction efficiencies were computed based on the amount of pigment present in the supernatant following 3X-FTS (PE545\textsubscript{3X-FTS}; Figure 5A) compared to the total amount of pigment (PE545\textsubscript{T}; Figure 5B) in the sample; PE545\textsubscript{T} was computed based on the total pigment extracted following two additional rounds of 3X-FTS plus an additional 3X-FTS extraction that included 1% SDS. PE545\textsubscript{T} was remarkable similar (no significant differences) for AB, TB and NaP at pH 6 (Figure 5B). PE545\textsubscript{T} was consistently high for NaP and TB over broad, but slightly different, pH ranges centered around pH 6. The high PE545\textsubscript{T} values at pH 6 -7 are not surprising; similar results have been shown repeatedly (Glazer 1982; Glazer 1989; Wedemayer et al. 1991; Wedemayer et al. 1992; Zhao et al. 2011). Somewhat unexpectedly, PE545\textsubscript{T} in AB was high only at pH6, declining markedly at both pH 5 and pH 7. PE545\textsubscript{T} in KP was a noted exception in most cases, due to what appeared to be insoluble KDS particles that co-precipitated with cell debris, including phycobiliproteins. These presumptive KDS particles reduced PE545\textsubscript{T} at all pH values tested. Two final comments relate to PE545\textsubscript{T} at the lowest and highest pH extremes: 1) at the lowest pH values (pH 1 – 3), pigment was frequently present in the cell pellets for AB, TB, and KP); and 2) at the higher pH values, substantial alterations in spectroscopic profiles were observed (e.g., pH 9 in all buffers where the PE545 absorption peaks are very blue shifted, indicative of pigment degradation).

![Figure 5 'First-round extraction' efficiency of PE545 following 3X-FTS treatment (PE545\textsubscript{3X-FTS}; A) and 'total extraction'efficiency' (PE545\textsubscript{T}; B).](image)

Turning now to PE545\textsubscript{3X-FTS} (the extraction efficiency during the first round of 3X-FTS; Figure 5A), extraction efficiency was low in all four buffers at both the three lowest (i.e., pH 1 – 3) and highest (i.e., pH 9) values tested (Figure 5A). PE545\textsubscript{3X-FTS} was more variable between pH 4 – 8 in the different buffers, though pH 5 – 7 tended to provide relatively high extraction in all four buffers. Importantly, PE545\textsubscript{3X-FTS} never exceeded 65%.
The long-term stability of the PE545\textsubscript{3X-FTS} extracts was examined for all buffer/pH combinations. The PE545\textsubscript{3X-FTS} samples were transferred to clean microfuge tubes (to eliminate interference from pigments trapped in the cell pellets), frozen at -20 °C for 2 days, thawed, and then incubated at 4 °C for 1 and 12 hr before recording absorption spectra (Figure 6). The initial absorption spectra were considered time $T_0$ for each buffer/pH combination and the value was set to 100\% for each buffer/pH combination (Figure 6); because $T_0$ was set at 100\%, the values in Figure 6 are difficult to compare to those in Figure 5. For instance, for NaP pH 1, pH3, and pH 6, the PE545\textsubscript{3X-FTS} values (taken from Figure 5) were 27\%, 10, and 56\%, respectively; these values were converted to 100\% for the $T_0$ values in Figure 6. One of the striking features of the stability curves revealed in Figure 6 is the high stability of pigments at the lower pH values (pH 1 and, in some cases, pH 2), with a rapid decrease in stability at pH 3 or 4 (depending on the buffer). In short, this corresponds to ‘low extraction efficiency (Figure 5) but high stability once extracted (Figure 6). There was a prominent ‘V’ shape to the stability profiles, as stability increased rather dramatically beyond pH 4 (pH 3 for TB) as the pH increased. Stability decreased above pH 7 (pH 6 for AB and pH 8 for TB). These complex stability profiles are difficult to explain, but are likely related to different aggregation states of PE545 (MacColl and Berns 1979), which is likely to impact both extraction efficiencies (Figure 5) and long-term stability (Figure 6).

![Figure 6](image)

**Figure 6.** Stability of PE545\textsubscript{3X-FTS} (from Figure 4) during long-term storage. The initial pigment content for each buffer/pH combination was set to 100\% and is referred to as $T_0$ in the text – and is drawn as a dashed green line in the plots above.

None of the buffer/pH combinations allowed complete phycobiliprotein extraction, even if the 3X-FTS was repeated several times (Figure 4A). Treatment of samples with SDS, but not urea, tended to result in complete extraction with several buffer/pH combinations; KP was a noted exception, due to what appeared to be insoluble KDS particles that co-precipitated with
cell debris, including phycobiliproteins.

4. Discussion and Conclusions

Phycobiliproteins have been extensively studied at the biochemical and biophysical levels, both in situ and in purified pigment-protein complexes. Isolated phycobiliprotein analyses generally include extraction in an aqueous buffer followed by ammonium sulfate precipitation and then one or more rounds of chromatography and/or different purification steps (Glazer 1982; Glazer 1989; Wedemayer et al. 1991; Wedemayer et al. 1992; Zhao et al. 2011). The purity of isolated phycobiliproteins can be estimated by the ratio of absorption of the pigment to that of the protein (e.g., $A_{545}/A_{280}$), where a low ratio is considered ‘crude’ (i.e., a preparation contaminated with many proteins, e.g., RuBPCase, one of the most abundant proteins in algae) while a high ratio is indicative of high purity. Protein concentration is an important component of phycobiliprotein stability (e.g., Glazer 1982); low protein concentrations being deleterious to maintaining the native conformation.

While comprehensive isolation and purification protocols are required for many studies, these protocols are not feasible when dealing with natural samples, either because the abundance of algae is very low and/or the number of samples involved is so large that multiple time-consuming and tedious steps cannot be routinely completed. Hence, it is virtually impossible to utilize pigment/protein ratios (e.g., $A_{545}/A_{280}$) as a measure of purity and it is difficult/impossible to maintain high protein concentrations in samples that are ‘thin’ in algal abundance. Hence, other approaches are required.

Work presented here represents initial steps aimed at combining acetone extraction and detergent-aided phycobiliprotein extraction from single samples, such as those collected during on-board research cruises. Simple, but not necessarily broadly applicable, methods based on fluorometric analyses of phycobiliproteins have been presented (e.g., Moreth and Yentsch 1970), but the extraction protocols appear to limit widespread utilization of the method (Wyman 1992).

Conclusions and Prospects: Extraction of PE545 from Rhodomonas salina grown in Daigo IMK medium was incomplete following procedures normally effective with cryptophytes (i.e., freeze-thaw-sonicate). Different buffers that covered a wide range of pH values (from pH 1 – 9) were tested to determine if PE545 extraction was enhanced. No buffer/pH combination was effective, with several buffer/pH combinations leading to co-extraction of chlorophylls and carotenoids. Extraction of cells with acetone (to remove chlorophylls and carotenoids) prior to extraction with aqueous buffers tended to lower PE545 extraction, unless SDS was included. The stability of the extracted PE545 was relatively high with buffers at pH values roughly centered on pH 6. The inclusion of an acetone extraction step is advantageous because it potentially allows analyses of all photosynthetic pigments (chlorophylls, carotenoids, and phycobilins) from the same sample, a noted advantage when dealing
with samples from field studies and/or at other times when sampling is limited by time, conditions, or circumstances. If both acetone extraction and SDS-induced solubilization are to be combined, it is important to understand the impacts of SDS on phycobiliprotein stability as well as the likely impacts on pigment extinction coefficients. Research with SDS, combined with urea, is currently being pursued with Rhodomonas salina as well as other marine algae in hopes of facilitating a broader inclusion of phycobilins in future environmental and/or ecological studies of marine and freshwater ecosystems.

5. Acknowledgements

We would like to thank Chulalongkorn University for financial support of this project including the Grants for Development of New Faculty Staff, Ratchadaphiseksomphot Endowment Fund (SB), and a Visiting Professorship position (FGP). Saskia Ohse provided the algal culture and helped with culture techniques; Ingon Thongcomdee (Algal Culture Lab, Department of Marine Science, Chulalongkorn University) provided help with algal cultures and associated methods.

6. References


ICCBES-1188

Change Analysis of Plant Diversity in Protected Horticulture Complex of Agricultural Ecosystems in South Korea

Jinkwan Son
National Academy of Agricultural Science, RDA, South Korea
E-mail address: son007005@korea.kr

Siyoung Lee
National Academy of Agricultural Science, RDA, South Korea
E-mail address: leesy42@korea.kr

Donghyeon Kang
National Academy of Agricultural Science, RDA, South Korea
E-mail address: kang6906@korea.kr

Minjae Kong
National Academy of Agricultural Science, RDA, South Korea
E-mail address: alswogud@dankook.ac.kr

Minjung Park
National Academy of Agricultural Science, RDA, South Korea
E-mail address: mjpark0107@korea.kr

Sunguk Yoon
National Academy of Agricultural Science, RDA, South Korea
E-mail address: wook@korea.kr

1. Background/ Objectives and Goals

The world is beginning to notice of various environmental issues, and the need to preserve the natural ecosystem, including those of agriculture and agricultural regions, has become ever important. However recently there have been various problems in agricultural landscapes. Therefore, research on the preservation and improvement of ecosystem services and biodiversity is essential. Among agricultural landscapes, protected horticultural complexes are considered to show reduced ecosystem service functions. This study investigates the plant diversity resulting from protected horticultural complexes. The size and arrangement of protected horticultural complexes and methods to promote plant diversity are also investigated using the attained results. This study can be used to create a model for developing eco-friendly and ecological horticultural complexes.
2. Methods
We investigated 4 land use types: paddy (p; 4 sites), glass greenhouse (g; 2 sites), single vinyl greenhouse (s; 2 sites), and multiple vinyl greenhouse (m; 2 sites). The locations investigated were Gumi (GM), Gimje (GJ), Buyeo (BY), and Jinju (JJ). Plant surveys were performed twice, in the spring and fall of 2015. Naturalized plants were analyzed according to family and taxa.

3. Expected Results/Conclusion/Contribution
The average distribution of plants for the four paddies was 23.3 ± 2.9 families (20–27) and 47.8 ± 2.9 taxa (43–51). Further, we recorded, on average, for the two glass greenhouses, 11.0 ± 2.8 families (9–13) and 22.0 ± 0.0 taxa; for the single vinyl greenhouses, 19.5 ± 2.1 families (18–21) and 31.5 ± 4.9 taxa (28–35); and for the multiple vinyl greenhouses, 14.0 ± 1.4 families (13–15) and 22.5 ± 2.1 taxa (21–24). According to number of species present, the land use types were listed in decreasing order as paddy > single vinyl greenhouse > glass greenhouse and multiple vinyl greenhouse. Therefore, plant diversity can be considered as dependent on the type of shelter. Furthermore, glass greenhouses and multiple vinyl greenhouses had approximately 50% less plant diversity than that in paddies. This needs to be supplemented to maintain a sustainable agriculture system.

The average distribution of naturalized plants in the four paddies was 5.8 ± 1.9 taxa (3–8). The distribution of naturalized plants for the 2 glass greenhouses was 8.5 ± 2.1 taxa (7–10); for the vinyl greenhouses, 4.0 ± 1.4 taxa (3–5); and for the multiple vinyl greenhouses, 7.0 ± 0.0 taxa. According to the number of naturalized plants, the land use types were listed in decreasing order as paddy and single vinyl greenhouse > glass greenhouse and multiple vinyl greenhouse(g: 8.5 > m: 7.0 > p: 5.8 > s: 4.0). However, the naturalization rate, calculated as a proportion of the total inhabiting plants, was 12.0% for paddies, 38.6% for glass greenhouses, 12.7% for single vinyl greenhouses, and 31.1% for multiple vinyl greenhouses, showing that glass greenhouses and multiple vinyl greenhouses have a high dependence for certain naturalized plants.

Therefore, it is necessary to improve plant diversity in glass greenhouses and multiple vinyl greenhouses. In addition, further improvements are necessary to increase the number of indigenous plants compared to the number of naturalized plants. Plant habitats need to be broadened to promote ecosystem service functions. Further studies must implement a model for the arrangement, size, and composition of protected horticultural complexes.

Acknowledgements
This study was carried out with the support of "Research Program for Agricultural Science & Technology Development (Project No. PJ010957)", NAAS, RDA, Republic of Korea.
Keywords: Vegetation, Greenhouse, Design, Ecosystem Service, Biodiversity
ICCBES-1189
Test on Characteristics of Internal Environment Special Variability in Plastic Greenhouse Using Computational Fluid Dynamics Simulation

Jae Su Lee
Farming Automation Division, National Institute of Agricultural Science, Korea
E-mail address: butiman@Korea.kr

Sang Cheol Kim
Farming Automation Division, National Institute of Agricultural Science, Korea
E-mail address: sckim7777@Korea.kr

Gook Hwan Kim
Farming Automation Division, National Institute of Agricultural Science, Korea
E-mail address: meceng93@Korea.kr

Young Gi Hong*
Farming Automation Division, National Institute of Agricultural Science, Korea
E-mail address: sanm70@Korea.kr

1. Background/ Objectives and Goals
Recently, has been focused a smart farm to take advantage of the convergence of Information and communications technology (ICT) technologies in agriculture. Especially, the plastic greenhouses are utilizing smart technology such as the Internet of Things (IoT) for the crops to try to control the environment more precise measurements inside and outside of the greenhouse. Moreover, although utilizing practical ICT devices came to control the environmental conditions of the greenhouse climate control system greenhouse the internal and external environmental conditions and user greenhouse set measured by various sensors, such as and so do not reflect the frequently changing greenhouse internal environmental conditions, it pointed out that difficult to optimize the growth of the crop has been raised continuously. In order to solve this problem, Cases analyzing ventilation characteristics of the plastic greenhouse by using the computational fluid dynamics (CFD) are increasing recently. The numerical analysis based on the CFD makes it possible to predict and analyze airflow characteristics of the model difficult to be analyzed by repeated experiment.

In this study, using a CFD simulation of the plastic greenhouse in order to design the application and installation methods for plastic greenhouses ICT equipment and analyzed the internal air flow characteristics. It was also evaluated by measuring the spatial displacement of the greenhouse internal environment.
2. Methods

We installed an experimental plastic greenhouse for analysis of plastic greenhouse internal environmental characteristics. The model was designed to the same plastic greenhouse actually manufactured by using the CATIA. Flow model was applied to a non-uniform grid and the number of grids is approximately 2.5 million. In this study, the fluid in the analysis region is assumed to be the steady-state incompressible three-dimensional turbulent flow. The numerical calculation of the airflow is generally based on aerodynamics with the mass, momentum, energy conservation equations. But radiative transfer, thermal conductivity and the thermal buoyancy were ignored because the heating elements were not considered. Therefore, energy conservation equation was not used. Realizable k-ε turbulent model used in this analysis have been studied to show more reasonable results than the standard model in wide fields of flow analysis. Using this, it was an internal air flow simulation analysis in accordance with the characteristics of greenhouse window opening rate.

For verification of a simulation model, the temperature and humidity sensor (U23-001, HOBO, USA) inside the plastic greenhouse was measured spatial variation of temperature and humidity distribution in accordance with the opening and closing amount of the windows installed in a matrix structure.

3. Expected Results/ Conclusion/ Contribution

We were analyzed for greenhouse environment ventilation and uniformity of the window opening and closing rate. Most greenhouse environment, it is largely determined by the ventilation efficiency and uniformity, the case of natural ventilation, depending on the opening rate of the standby wind speed and windows, in the case of forced ventilation, depending on the capacity and installation location of the exhaust fan, efficiency and uniformity is affected. The results of the simulation environment to improve the non-uniformity of the greenhouse area in a predetermined opening ratio to reflect the conditions of the window were tested for uniformity improvement of the greenhouse environment. If there are about 2 m/s or more wind speed, non-uniformity in the area of the environment situated in conjunction greenhouse top was higher than in the other areas. To improve this, to different opening ratio in the upper side of the window and the lower side of the window, it is possible to improve the uniformity of a substantial portion of the environment. And if the air velocity is less than or equal to about 2 m/s, when there is no wind, it showed a tendency to non-uniformity of the lower side is increased compared to other areas in the greenhouse. An additional study on the forced ventilation and proper arrangement of flow through the ventilation fan and the fan is considered necessary. In order to maintain the cultivation environment within the greenhouse uniformly therefore, it is necessary to differently each opening ratio of the window based on the position and arrangement of the greenhouse. These characteristics should be included in the
environment control algorithm in a plastic greenhouse management.

Keyword(s): CFD, Smart farm, Spatial variation, ICT, Greenhouse
ICCBES-1220
Isolation and Characterization of Bacterium that Promotes the Antibiotic Production in the Presence of Rice Husk Biochar

Shohei Ebe, Tatsuya Ohike, Masahiro Okanami, Takashi Ano
Grad. Sch. BOST, Kindai Univ. Japan
E-mail address: bd5002es@waka.kindai.ac.jp

1. Background/ Objectives and Goals
Rice husk biochar (RHB) is produced by low-temperature pyrolysis of rice hulls. Plant cells such as tracheids remain as ventricles in biochar after carbonization. RHB has been traditionally used as soil amendment for improvement of drainage properties and air permeability in soil in Japanese agriculture. Addition of RHB has been known to promote plant growth (Warnock, D. D. et al. 2005). Although several mechanisms have been proposed, these mechanisms are poorly understood. One of the mechanisms that have been reported is that RHB added in soil enhances the activity of rhizosphere microorganisms in soil (Chan, K. Y. et al. 2005).

The purpose of this study is to isolate the microorganisms of which the growth is promoted in the presence of RHB, and explore the mechanisms involved in the plant growth promotion in the presence of RHB.

2. Methods
Microorganisms were isolated from environmental samples using 1/10 TSA (Bacto-peptone, 2 g; glucose, 0.25 g; K₃HPO₄, 0.25 g; NaCl, 0.5 g; agar, 1.5% (w/v); in 1 liter of distilled water). Isolated strains were cultured in LB medium, and each of the 10 µL of culture media was inoculated at the center of 1/10 TSA supplemented with and without 0.5% (w/v) AC and incubated at 30°C. The growth areas on the plates were compared. Microorganisms with larger growth area on AC plate were screened. The screened microbes were further tested on the plate containing 0.5% (w/v) RHB in the similar way as described above.

Plant pathogenic fungi Rhizoctonia solani was used in the antifungal activity test. Microbes with antifungal activity were cultured using TSB medium at 30°C with shaking (120 rpm). The culture media were centrifuged at 20,000 × g for 10 min, and the supernatant was filtered through a DISMIC-25cs membrane (0.20 µm; ADVANTEC TOYO Company, Tokyo, Japan). The sterilized culture supernatants were used for antifungal activity tests.

3. Expected Results/ Conclusion/ Contribution
A microbe with enhanced growth on 1/10 TSA supplemented with RHB was isolated and
named as IA (Fig.1). The number of total and spore cells of IA was increased in TSB medium supplemented with 0.5% (w/v) RHB (data not shown). Furthermore the antifungal activity of the culture supernatant was higher than those of other supernatants as shown in fig. 2.

In conclusion, we have successfully isolated the microorganism with enhanced growth and antibiotic production in the presence RHB.

![Image 1](image1.png)

**Fig. 1:** The growth of strain IA on 1/10 TSA plate with carbon. Growth of strain IA was assessed on 1.5% agar 1/10 TSA (A). Growth area was measured (B).

![Image 2](image2.png)

**Fig. 2:** Antifungal activity of strain IA culture supernatant against *R. solani* on PDA. These stainless cups contained 200 μL sterilized water (A), supernatant of the TSB culture medium (B), supernatant of the TSB culture medium supplemented with AC (C) and supernatant of the TSB culture medium supplemented with RHB (D).

4. References


Keywords: biocontrol agent, rice husk biochar, bacterial growth enhancement
1. Background/ Objectives and Goals

In South Korea, about 30 percent of the protected horticulture farms cultivate crops with heating greenhouses in winter, and areas of heating greenhouses have increased steadily for its high value-added products. Heating cost for heating greenhouses takes 30~40 percent of the working expenses of the horticulture farm and acts as a main pressuring factor of farm management. Nevertheless, about 85 percent of horticultural farmers use oil for heating fuel, and new and renewable energy use including geothermal heat pump accounts for only 0.9 percent of the heating energy of horticulture facilities. In this study, high performance air-to-water heat pump system for heating greenhouses was developed and the effect of energy consumption saving and reduction in CO2 emission of developed systems were estimated.

2. Methods

A greenhouse heating system to improve air source heat pump performance using inside and outside air heat of greenhouse as a heat source selectively was developed. In this system, thermal storage modes divided into the inside circulation mode using surplus solar heat discharged outside of greenhouse to maintain the greenhouse temperature properly and the outside circulation mode using greenhouse outside air heat. The thermal storage modes were designed to be switched mutually according to greenhouse inside temperature set in advance. Six temperature values were input to control the heat pump operating, thermal storage mode switching and greenhouse heating automatically.

3. Expected Results/ Conclusion/ Contribution

Prototype heating system was tested in a plastic greenhouse without crop to investigate the operating characteristics, and the results showed that the inside circulation mode began at about 11:00 and lasted for about 210 minutes and inside greenhouse temperature was maintained between 20~28℃ in spite of non-ventilation. System heating COP (Coefficient of performance)
of the inside circulation mode in daytime was 3.35, which was 36% and 25% higher than that of the outside circulation modes in the nighttime and daytime respectively. Improved field test model with heat pump of 70kW in closed room and thermal storage tank of 20 tons under splitting temperature control was designed and installed in a plastic greenhouse of rose cultivation. According to the results of the field test, the system heating COP of the inside circulation mode using surplus solar heat in daytime was 3.0~4.5 higher than that of 2.5~2.9 of the outside circulation mode using greenhouse outside air heat in night time. Average system heating COP of field test model was estimated at about 3.1 which was 32% higher than that of conventional air to water heat pump using outside air heat with thermal storage tank. Installation cost of present system was about 15% higher than that of conventional air to water heat pump, but about 40% lower than that of vertical closed-loop ground source heat pump. Heating cost and carbon dioxide emission of present system were estimated to be 20% and 58% respectively compared to conventional light oil hot air heater.

Acknowledgements
This study was carried out with the support of "Research Program for Agricultural Science & Technology Development (Project No. PJ008530)", NAAS, RDA, Republic of Korea.

Keywords: COP(Coefficient of performance), Heating cost, Horticulture greenhouse
ICCBES-1240

Meng-Shian Tsai, Chia-Jung Lu
aDepartment of Chemistry, National Taiwan Normal University, Taiwan

Pi-Guey Su*
Department of Chemistry, Chinese Culture University, Taiwan
spg@faculty.pccu.edu.tw

Abstract
Novel electrochemical sensor was made of WO3/graphene nanocomposite modified glassy carbon electrode (GCE) for the simultaneous determination of hydroquinone (HQ) and catechol (CC) in solution. WO3/graphene nanocomposite films were synthesized by a one-pot chemical process which was combined with the metal organic decomposition (MOD) method. The WO3/graphene nanocomposite film was characterized by fourier transform infrared spectroscopy (FTIR), X-ray diffractometry (XRD), electrochemical impedance spectroscopy (EIS), scanning electron microscopy (SEM) and atomic force microscopy (AFM). Under optimized conditions, the electrochemical behaviors of HQ and CC could be completely distinguished and avoid interference from each other on the WO3/graphene electrode using cyclic voltammetry (CV) and differential pulse voltammetry (DPV). The proposed electrochemical sensor exhibited wide linear responses from 0.07 to 50 μM with the detection limits 0.05 μM for the simultaneous detection of HQ and CC. In addition, the sensor also had a strong response, excellent reproducibility of fabrication and excellent operational repeatability.

Keywords: Electrochemical analysis; simultaneous detection; hydroquinone and catechol

1. Introduction
Hydroquinone (1,4-dihydroxybenzene, HQ) and catechol (1,2-dihydroxybenzene, CC) are important sources of environmental contamination owing to their extensive use in the production of dyes, photostabilizers, cosmetics and pesticides. Therefore, a new method for simultaneously detecting HQ and CC is required. An electrochemical sensor has the advantages of high sensitivity, simplicity of operation and effectiveness in monitoring HQ and CC. However, simultaneously detecting HQ and CC using conventional electrodes, such as glass carbon and gold electrodes, is difficult because their redox peak potentials are too close to distinguish. Therefore, glass carbon and gold electrodes for this purpose must be modified. Recently, many RGO-based materials have been used to modify glass carbon electrodes (GCE)
for simultaneously sensing HQ and CC; they include thermally reduced graphene oxide (TRGO) [1], graphitic mesoporous carbon (GMC) [2], tungsten sulfide (WS$_2$)-graphene [3] and graphene and titanium dioxide (TiO$_2$) nanoparticles [4]. In this work, a glassy carbon electrode (GCE) that was modified using a nanocomposite film of WO$_3$ and RGO (WO$_3$/RGO/GCE) was fabricated to detect simultaneously HQ and CC in a binary mixture.

2. Experimental

2.1 Fabrication of Electrochemical Sensors Based on RGO/WO$_3$ Nanocomposite Films

GO was prepared from natural graphite by Hummers method [5]. The RGO/WO$_3$ nanocomposites were synthesized as follows. Tungstic acid (H$_2$WO$_4$) (3.0 g) and the required amounts of GO were added to 10 g of glycerol and the resultant solution was heated to 190°C for 1 h with vigorous magnetic stirring. The solution was continuously stirred until a stable suspension was obtained. The level of doping with GO was varied among 1.6 wt%, 3.2 wt% or 11.8 wt% of H$_2$WO$_4$. The RGO/WO$_3$ nanocomposite films were formed by MOD in the same manner as used in the fabrication of a gas sensor based on a WO$_3$ film. For fabricating the RGO/WO$_3$ nanocomposite films, an MOD temperature of 500°C was maintained for 4 h.

2.2 Instruments and Analysis

The surface microstructure of the WO$_3$ film and RGO/WO$_3$ nanocomposite films coated on an alumina substrate was investigated using a field emission scanning electron microscope (FEI company, Nova NanoSEM™ 230) equipped with an energy dispersive spectrometer (EDS) and an atomic force microscope (AFM, Ben-Yuan, CSPM 4000) in tapping mode which the horizontal and vertical resolution are 0.26 and 0.10 nm, respectively. The XRD powder pattern of the WO$_3$, GO and RGO/WO$_3$ nanocomposite films were measured using Cu K$_{α}$ radiation (Shimadzu, Lab XRD-6000). Electrochemical impedance spectroscopy (EIS) and cyclic voltammetry (CV) measurements were performed using an electrochemical workstation (ZAHNER ZENNIUM, Germany) with standard three-electrode cell. Differential pulse voltammetry (DPV) was used in scan mode to simultaneously detect HQ and CC and the potential ranged from −0.4 to 0.4 V with a scan step-height (Incr) of 5 mV, a pulse-height (amplitude) of 50 mV, a step-width of 50 ms and a pulse-width (sampling width) of 20 ms. The working electrode was a gold electrode; the auxiliary electrode was a platinum wire and the reference electrode was a saturated calomel electrode (SCE). The interfacial characterization of the electrode was performed in a 10 mM K$_3$[Fe(CN)$_6$]/K$_4$[Fe(CN)$_6$] (1:1) mixture (with 0.1 M NaCl as the supporting electrolyte) using faradic EIS. The applied voltage as 0.18 V and frequency range from 100 mHz to 100 kHz at 25°C were chosen for the EIS analysis. All the measurements were made at 25 ± 1°C.

3. Results and Discussion

3.1 Characterization of WO$_3$/RGO/GCE
Electrochemical impedance spectra (EIS) of the RGO/GCE, \(\text{WO}_3/\text{GCE}\) and \(\text{WO}_3/\text{RGO}/\text{GCE}\) were obtained to characterize their interface properties. The diameter of the semicircle at higher frequencies in the Nyquist diagram that was obtained by EIS yields the interfacial electron transfer resistance (Ret), which determines the electron transfer kinetics of the redox probe at the electrode surface. Figure 1 presents the Nyquist diagrams that were obtained from the EIS of the RGO/GCE, \(\text{WO}_3/\text{GCE}\) and \(\text{WO}_3/\text{RGO}/\text{GCE}\). When the GCE was modified with RGO, the curve was an almost straight line because of a very low resistance to interfacial electron transfer because of the formation of a new conductive path by the RGO. When the GCE was modified with \(\text{WO}_3\), the curve exhibited a high Ret because the \(\text{WO}_3\) was semiconductor metal oxide. When the GCE was modified with \(\text{WO}_3/\text{RGO}\), the Ret decreased to a small value, owing to the formation of a conductive path by the RGO. This phenomenon clearly suggests that the \(\text{WO}_3/\text{RGO}\) film was successfully modified on the GCE surface.

![Nyquist Diagram](image)

**Fig. 1** Electrochemical impedance spectra of RGO/GCE, \(\text{WO}_3/\text{GCE}\) and \(\text{WO}_3/\text{RGO}/\text{GCE}\).

### 3.2 Simultaneous Quantification of HQ and CC Using \(\text{WO}_3/\text{RGO}/\text{GCE}\)

The individual quantifications of HQ and CC in a mixture were firstly performed on the \(\text{WO}_3/\text{RGO}/\text{GCE}\) with the concentration of one species held constant. Figure 2 plots the response curves of the \(\text{WO}_3/\text{RGO}/\text{GCE}\) to a binary mixture that contained an increasing concentration of CC from 0.06 to 10 \(\mu\text{M}\) and a constant concentration of HQ of 1 \(\mu\text{M}\). The inset in Fig. 2 plots the response current of the \(\text{WO}_3/\text{RGO}/\text{GCE}\) versus the concentration of CC. The linear regression was quite linear \((Y = 4.6386 X + 14.19; R^2=0.9766, \text{where} \ Y \text{is the response current (}\mu\text{A}); \ X \text{is the concentration (}\mu\text{M}); \text{and} \ R^2 \text{is the correlation coefficient})\) from 0.06 to 10 \(\mu\text{M}\). Figure 3 plots the response curves of the \(\text{WO}_3/\text{RGO}/\text{GCE}\) in HQ at various concentrations in the presence of 1 \(\mu\text{M}\) CC. The inset in Fig. 3 plots the response current of the \(\text{WO}_3/\text{RGO}/\text{GCE}\) versus the concentration of HQ. The response current of HQ linearly increased with the concentrations of HQ from 0.08 to 20 \(\mu\text{M}\) \((Y = 2.5701 X + 16.837;\))
$R^2=0.9616$, where $Y$ is the response current ($\mu$A); $X$ is the concentration ($\mu$M), and $R^2$ is the correlation coefficient). Detection limits (D.L.) were calculated as three times the standard deviation from seven replicate measurements of the blank sample. The D. L. for HQ and CC both were 0.05 $\mu$M.

![Graph showing Current ($\mu$A) vs Potential (V) for HQ and CC](image)

Fig. 2 Response of WO$_3$/RGO/GCE to binary mixture of fixed concentration, 1 $\mu$M, of HQ and various concentrations from 0.06 to 10 $\mu$M, of CC. Inset: calibration plot of CC.
4. Conclusion

A novel WO$_3$/RGO was synthesized and used to modify gold carbon electrodes to form electrochemical sensors for simultaneously quantifying HQ and CC using DPV. The WO$_3$/RGO/GCE exhibited two well-distinguished anodic peaks and a stronger response current in HQ and CC than did the RGO/GCE and WO$_3$/GCE. Introducing RGO effectively improved the ability of the WO$_3$/RGO/GCE to discriminate between HQ and CC and its sensitivity to them, because RGO provided conduction pathways and exhibited strong electro-catalytic activity.

Acknowledgement

The authors thank the Ministry of Science and Technology (grant no. MOST 104-2113-M-034-001) of Taiwan for support.

References


Evaluation of Greenhouse Gases Emissions from Wastewater Treatment Plant in Taiwan

Jen-Po Hung*
National Taipei University, Taiwan.
E-mail address: antory0218@hotmail.com

Ying-Chu Chen
National Taipei University, Taiwan
E-mail address: ycchen@mail.ntpu.edu.tw

1. Background/ Objectives and Goals
The "United Nations Framework Convention on Climate Change (UNFCCC)” signed in 1992 and the "Kyoto of the Protocol” in 1997 have developed important goals to reduce emissions of greenhouse gas (GHG) to the standard in 1990. Many countries have set concrete actions to control GHGs according to the national protocols. However, most actions and researches are focus on GHG emissions from industries. Some major constructions, i.e. incinerators and wastewater treatment plants (WWTPs), also contribute to great amount of GHGs. They should be carefully managed. This research aimed to develop a model to accurately estimate potential of GHG emissions from WWTPs in Taiwan. Suggested measures of GHG mitigations were also provided specifically in this study.

2. Methods
The three parts of this study include literature review, model development, and in-situ verifies. Unit operation of standard WWTP was collected from literatures review. Properties of influent and/or effluent wastewater affected on-site GHGs and some ancillary facilities (such as pumps, mixers, and dosing instrument) affected off-site GHG emissions were all evaluated. Base on above information and data, proper model was developed and one specific WWTP in Taiwan was chosen as a case study to verify the accuracy and reasonableness of the model established in this study.

3. Expected Results/ Conclusion/ Contribution
The results of this study can be an example of GHG emissions from WWTPs. Suggested operating procedures and instrument can be applied to evaluate their GHG mitigations with regards to meet national goals.

Keywords: greenhouse gas, model, Taiwan, wastewater treatment plant
Impacts of Travel Motivation and Experience of Tourists on Word-of-Mouth and Revisit Intention of Lighthouse

Chen-Chieh Sheng*  
National Taipei University, Taiwan.  
E-mail address: ccsheng@motcmpb.gov.tw

Ying-Chu Chen  
National Taipei University, Taiwan.  
E-mail address: ycchen@mail.ntpu.edu.tw

1. Background/ Objectives and Goals
Development of travel services have grown much faster than other services worldwide (WTTC, 2014). Researches found that nature-based tourism has become an important role with unique ecological resources and landscapes (Andersson, 2007; Lee, 2009). In Taiwan, over 90% people travel domestically seven times each year (Tourism Bureau, 2014). Taiwan government has promoted domestic travel of lighthouses since 1992 to enhance tourists’ understanding of the natural resources and landscapes. Therefore, it is important to understand tourists’ motivations of traveling lighthouses. This study aimed to find out the factors that may affect tourists’ word-of-mouth and revisit intention to visit the lighthouses in Taiwan. A theoretic model to depict the relationships among these factors and consequences were conducted in this study.

2. Methods
The Self-Determination Theory (SDT) (Deci and Ryan 1985) and experience literatures (Poulsson and Kale, 2004) were used to establish the theoretic model in this study. In the SDT, an individual’s self-regulatory styles for behavior can be induced by different level of intrinsic and extrinsic motivations. Moreover, their actions as self-determined and volitional were considered to satisfy with their action. According to the Poulsson and Kale (2004), experiences are defined as an individual mental status aroused by a specific activity. Hosany and Witham (2010) also discussed that tourists’ on-site experience positively affects their travel satisfaction and loyalty.

Based on the theories mentioned above, the established research framework is shown in fig. 1. A questionnaire-based survey was designed to collect the data needed for this study. Visitors who had the travel experiences of the lighthouses will be invited to complete the survey. This study is expected to have over 200 valid responses applied for the modeling analysis.
3. Expected Results/ Conclusion/ Contribution

This study expects to receive tourists’ positive responses on their satisfaction of traveling lighthouses. Moreover, the satisfaction may have positive impacts on their word-of-mouth and revisit intention in the future. This study has connected tourists’ travel motivation and experiences. The results of this study may get useful information from tourists for regional government to improve relative travel services.

Keywords: Experience; Lighthouse; Revisit intention; Travel motivation; Word-of-Mouth

![Figure 1. Research Framework](image)

Reference

World Travel & Tourism Council (2014). http://www.wttc.org/
Carbon Capture by Dissolution of Carbonate Minerals

Ming-Hui Chang*, Pei-Shan Hsieh, Kuo-Wei Huang, Chuan-Wei Chung, Chi-Wen Liao, Heng-Wen Hsu
Green Energy and Environment Research Laboratories
Industrial Technology Research Institute, Taiwan
E-mail address: mirandachang@itri.org.tw

Yi-Tun Hsu
Department of Chemical Engineering
Ming-Chi University of Technology, Taiwan

Abstract
The aim of this research was to capture carbon dioxide in the flue gas and convert it into bicarbonate ions by dissolution of carbonate minerals. A bench-scale testing system, mainly compose of a bubbling tank reactor and a fluidized-bed reactor, had been constructed to capture CO₂ as a gas flow rate of 3 L/min. First, the CO₂-rich flue gas was fed into the bubbling tank through a gas distributor to let CO₂ dissolve into the solution. In the second stage, this acidic solution was pumped into a fluidized-bed reactor to contact with the carbonate mineral powders, and resulting in the carbonate minerals dissolution, and finally formed bicarbonate ions. The CO₂ concentration in the gas stream and the calcium ion concentration in the liquid stream had both been measured to calculate the CO₂ capture efficiency and the carbonate dissolution rate. In the bubbling tank, two types of gas distributors had been tested: a perforated plate and a microbubble generator. The results had been shown that the CO₂ dissolution efficiency using the microbubble generator was significantly higher than that of the perforated plate. On the side of the fluidized-bed reactor, the dissolution efficiency of the carbonate mineral increased when the residence time of the liquid increased. As the carbonate mineral offcut powders were used as the solid reactant, a higher pH value of the product solution could be reached than that as limestone was used, due to that there were some metal oxide contained in the mineral offcut powder. In the nannochloropsis cultivation test, the nannochloropsis amount obtained from the product solution and the artificial seawater showed no significant difference, showed the product solution might be harmless to the organisms in the ocean.

Keywords: CO₂ capture, Limestone, Offcut, Fluidized-bed, Gas distributor

1. Background/Objectives and Goals
Emission of carbon dioxide, from combustion of the fossil fuels, is expected to continuously increase with the global development of industry and economy, causing serious threat to the
climate change. In order to mitigate this problem, there has been extensive effort in most of the developed countries to promote the use of bio-mass and renewable energy. However, the power generated by the low-carbon-emission energy sources is not sufficient enough to meet the global needs. Therefore, the capture and separation of CO₂ from the present emission sources, which is the so-called CCS process (Carbon Capture and Storage), seems to be the most effective mitigation option for climate change. Many CO₂ capture technologies had been developed, and most of them were to separate CO₂ from the flue gas by using a sorbent and a solvent first, and then the CO₂ was purified and transported to the suitable site for further mineral sequestration. On the side of the one-step CO₂ capture and storage method, one of the most particular methods is to convert the CO₂ into bicarbonate ions for storage in the water-solution directly, using the reactions of weathering of limestone.

Common weathering phenomenon is very slow because of the low partial pressure of CO₂ in atmosphere. As the partial pressure of CO₂ increased, the reaction rate can be accelerated, and this method is the so-called Accelerated Weathering of Limestone (AWL), which was mainly mentioned and developed by Rau and Caldeira (1999). In the system design of this method, Rau & Caldeira (1999) mentioned the C₂SEA system, of which the reactant solution was sprayed into the bed filled with limestone, was estimated to treat 20% CO₂ released from a 500MW coal-fired power plant (Rau et al., 2007), but the volume of the reactor was 216,000 m³ because of the slow reaction rate. In the lab-scale experiment reported by Rau (2011), 61-85% CO₂ dissolution efficiency can be reached, and of which limestone and aragonitic coral fragments were used as the solid reactants packed in a column to progress the gas-liquid-solid reaction. In order to improve the CO₂ capture efficiency and to reduce the volume of this process, a bench-scale, two-step reaction process, has been designed and constructed in this research. In addition, the released product solution of this process has been also used for the algae cultivation, to understand the influence to the downstream organisms in the ocean. The primary estimation of the influence to the ocean of the product solution in the lab-scale system has been reported by Chou et al. (2015).

2. Methods

Fig. 1 shows the concepts of the main reactions used in this study. There are two main reactors in this system: one is for gas-liquid reaction and one is for liquid-solid reaction. At the first stage, the flue gas is fed to contact with reactant solution, which results in the transformation of CO₂(g) to CO₂(aq) that is composed primarily of carbonic acid that mostly dissociates, thereby forming H⁺ and HCO₃⁻ ions. At the second stage, this acid solution is led to contact with carbonate mineral particles, which results in dissolution of carbonate minerals and formation of a solution enriched with Ca²⁺ and HCO₃⁻ ions. In this CO₂ capture system, the dissolution of the carbonate minerals represents the CO₂ transform to the bicarbonate ion instead of CO₂(aq), means the real parts of CO₂ being captured and stored in the solution, and it was equal to the
calcium ion deviation in the inlet and outlet solution.

A schematic diagram of the system used in this study is shown in Fig. 2. It consists of the liquid feeding system, gas feeding system, two main reactors, and a liquid collection tank (10). The liquid feeding system includes two centrifugal pumps (7), two liquid rotameters (8), and a liquid storage tank (6). The gas-liquid reactor (4) is an acrylic bubbling tank with a volume of 100 L(W40cm × L50cm × H50cm). The gas distributor in the bottom of tank is a perforated plate with holes of 1 mm in diameter. The other gas feeding system is to pump the feeding gas through a microbubble generator (3), which can produce bubble with diameter of less than 0.2 μm. The liquid-solid reactor (9) is a fluidized-bed with a diameter of 15 cm and a height of 70 cm, and there is a stainless steel perforated plate with 1 mm hole diameter and a #140 stainless steel mesh in the bottom of the fluidized-bed. The pH values of the storage tank, bubbling tank, and the collection tank are monitored by the pH meter (12) through the three pH electrodes (11). On the hand of the solid reactants used in this study: one is the limestone powder (>95 wt% CaCO₃) with 350-840 μm in diameter, and the other is the offcuts powder of carbonate mineral (~78 wt% CaCO₃) with <20 μm particle size.

At the beginning, 100 L test water was fed into the bubbling tank. When the flue gas (15% CO₂) was fed into the bubbling tank at a flow rate of 2~3 L/min, the pH value started decreasing due to the CO₂ dissolution. As this reaction progressed continuously, the CO₂ dissolution rate was decreased as the acidity of the solution increased. As the pH value decreased to about 6.2, the CO₂ dissolved very slowly, therefore this first-stage reaction was stopped. At the second stage, the CO₂-rich solution was pumped into the liquid-solid reactor to pass through the bed full of 9.14 kg solid reactant. The liquid flow rate was controlled at 1.5 ~14 L/min to slightly agitate the particles to enhance the solid dissolution rate. The pH value of the product solution was measured as higher than 6.5, and the solution was collected for the follow-up analysis.

Fig. 1: The concepts of the reactions in the two reactors
The solutions were sampled to measure the concentration of calcium ions by inductively coupled plasma analyzer (ICP, Perkin Elmer Optima 2100 DV). The CO\textsubscript{2} concentration of the inlet and outlet gas streams of the bubbling tank was analyzed by a gas chromatography analyzer (GC, Agilent Technologies 7890A). The product solution was mixed with artificial seawater by different ratio for the \textit{nannochloropsis} cultivation for 2 days under supplying LED light continuously, and the number of \textit{nannochloropsis} was counted by using a counting chamber (MARIENFELD Neubauer- improved counting chambers).

3. Results

The CO\textsubscript{2} capture system had been tested starting from unit operation to the full-system operation. In the bubbling tank, two types of gas distributor had been tested: a perforated plate and a microbubble generator. On the side of the fluidized-bed reactor, the effect of the liquid flowrate on the dissolution rate of limestone had been obtained. In addition, carbonate minerals offcut powder had been used as the solid reactant, and the results of calcium dissolution had been compared with that of limestone. Finally, flue gas (containing \textasciitilde22\%CO\textsubscript{2}) of a cement plant had been used for the full system continuous operating test to obtain the carbon capture efficiency and conversion. In order to reduce the cost of the reactants, seawater should be used as the reactant solution for the further scale-up system, and the influence of the product solution released to the ocean should be estimated, and in this research the \textit{nannochloropsis} cultivation using the product solution had been progressed.

3.1 CO\textsubscript{2} Capture Efficiency in the Bubbling Tank

In the batch operation test of the bubbling tank, the gas of different content of CO\textsubscript{2} was pumped into the bubbling tank contained of 100 L tap water. The pH value had been monitored and the CO\textsubscript{2} concentration of the outlet gas stream had been measured to calculate the CO\textsubscript{2} capture efficiency. There are two kinds of gas distributor tested in this experiment: a
microbubble generator and a perforated plate. The gas flowrate had been tuned at 2 L/min and 3 L/min, and 3 L/min was the higher limit of the microbubble generator. The CO$_2$ concentration of the inlet gas was controlled at 15%, 30%, and 100%, in order to approach the flue gas concentration of a normal coal-fired power plant (~15% CO$_2$) and a cement plant (22~30%CO$_2$).

The change of the pH value in the bubbling tank was shown in Fig. 3. As 100% CO$_2$ was pumped and dissolved into the solution for 24 mins, the pH value of the solution decreased from neutral to 5.1 by using a microbubble generator and 5.3 of using a perforated plate, respectively. It was shown that the CO$_2$ dissolution efficiency of that using the microbubble generator was significantly higher than that of the perforated plate. The results of different gas flowrate and CO$_2$ concentration were shown in Table 1. In Table 1, the change of the pH value and CO$_2$ capture efficiency was measured at the 4$^{th}$ min and the 8$^{th}$ min after pumping the gas into the solution. It can be seen that as the CO$_2$ concentration was 100%, the pH difference and the CO$_2$ capture efficiency using the microbubble generator were both significantly higher than that of the perforated plate. This might be due to that the submicron bubble has more surface area contacting with the reactant solution, thus improving the CO$_2$ dissolution rate. As the CO$_2$ concentration were 15% and 30%, the pH value of that using the two gas distributors showed no significant difference, might be due to the performance of the microbubble generator was weaker when mixing the CO$_2$ with N$_2$. However, the CO$_2$ capture efficiency of that of microbubble generator was maintained higher than that of the perforated plate. Based on these results, in the full-system operation, the microbubble generator was chosen for further experiment.

**Fig. 3:** The pH value of the bubbling tank using the different gas distributor. Fixed operating conditions: 100%CO$_2$, gas flowrate of 3 L/min, reactant solution: 100 L tap water.
3.2 Carbonate Minerals Dissolution in the Fluidized-Bed Reactor

Fluidized-bed is one of the common liquid-solid reactors used in industry, not only due to the high mixing efficiency but also the suitability for continuous operation. In this kind of reactor, the most important parameter is the residence time of the reactant solution contacting with the solid reactants. In order to obtain the effects of the residence time to the dissolution rate of the calcium minerals, the reaction solutions was first passed through the bubbling column to dissolve CO₂, and then pumped through the fluidized-bed at the flowrate increased from 4 L/min to 14 L/min, and the results were shown in Table 2. As the liquid flow rate increased from 4 to 14 L/min, the residence time decreased from 100.73 s to 40.90 s, thus the calcium ion deviation decreasing from 46.62 to 27.24 ppm, meaning that the efficiency of the CO₂ transformation decreased, and thus the decreasing of the pH value of the product solution. However, the calcium dissolution rate increased from 186.46 to 381.29 mg/min, contributing from the increasing flowrate of the reactant solution, meaning the increasing of total amount of the CO₂ conversion. In summary, the increasing of the liquid flowrate decreases the residence time, thus decreasing of the efficiency of the CO₂ conversion, and simultaneously increases the pumping cost and the energy consumption of this system, which should be avoided in the operation of the scale-up system in the future.

<table>
<thead>
<tr>
<th>Gas distributor</th>
<th>inlet CO₂ concentration (%)</th>
<th>inlet gas flowrate (L/min)</th>
<th>Time (min)</th>
<th>ΔpH</th>
<th>CO₂ capture efficiency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>microbubble</td>
<td>100</td>
<td>3</td>
<td>4</td>
<td>-1.34</td>
<td>99.73</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>-0.81</td>
<td>98.1</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>2</td>
<td>8</td>
<td>-1.09</td>
<td>76.6</td>
</tr>
<tr>
<td>perforated plate</td>
<td>100</td>
<td>3</td>
<td>4</td>
<td>-1.23</td>
<td>65.93</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>2</td>
<td>8</td>
<td>-1.46</td>
<td>35.4</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>2</td>
<td>4</td>
<td>-0.77</td>
<td>74.48</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>-1.08</td>
<td>56.76</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>-0.38</td>
<td>82.13</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>-0.93</td>
<td>47.57</td>
</tr>
</tbody>
</table>
3.3 Performance of the Two Kinds of Carbonate Minerals

Limestone was chosen to be the solid reactant due to the high carbonate content. However, the cost of the raw material should be considered in the further commercial-scale system. In this research, offcut powder of the carbonate minerals, which is waste in the mining industry, has been tested as a substitution for the solid reactant, and the performance has been compared with that of limestone.

In this experiment, the solid reactant had been stirred in 2 L reactant solution output from the bubbling tank of pH 5.35. The pH value had been monitored and the calcium ion concentration was measured at the 20th min to obtain the average dissolution rate. As shown in Table 3, as the weight of solid reactant increased from 25 g to 250 g, the calcium ion deviation increased significantly from 24.80-35.59 ppm to 105.48-108.66 ppm, and the calcium dissolution rate increased from 2.48-3.96 mg/min to 10.55-10.87 mg/min, no matter which solid reactant had been used. It could be conjectured that the more the solid reactant, the more the surface area of liquid-solid interaction, and resulting in the higher dissolution rate. Although the similar solid dissolution rate had been obtained by using the two solid reactants, a higher pH value of the product solution could be reached when using the offcuts than that of limestone. This might be due to that there was some metal oxide contained in the mineral offcut powder. In addition, it was advantageous for the future scaling-up system operation because of the product solution released from this CO₂ capture system was close to neutral, which reduces the influence to the organisms in the downstream.
3.4 Continuous Operation Test of the Full-System

The full-system operation had been set up within the Taiwan Cement Cooperation Plant in Heping in the eastern Taiwan to capture the CO\textsubscript{2} contained in the flue gas of the cement rotary kiln. The bubbling tank has been enlarged to contain 200 L reactant solution to avoid the microbubble generator losing the operating pressure. In the beginning, the bubbling tank was filled with 200 L tap water, and the flue gas contained about 22% CO\textsubscript{2} had been pumped into the tank. As the pH decreased to around 6.2, the liquid pump was turned on to start the continuous full-system operation. The gas flowrate was controlled at 3 L/min, and the liquid flowrate was controlled at 1.5 L/min as low as enough to increase the liquid residence time in the fluidized-bed to enhance the solid dissolution efficiency. The solid reactant was 8.33 kg offcut powder.

The results were shown in Fig. 4. As shown in the figure, at this operating condition, the pH value of the bubbling tank can be maintained stably at about 6.0~6.1, and the pH of the product solution was stable at about 7.2 after 10 mins as the particle surface fully wetted. The CO\textsubscript{2} capture efficiency was also stable at around 90%, representing the stable operation of the full system, and the CO\textsubscript{2} capture rate can be calculated as 1.18 g/min. The calcium ion concentration was maintained at around 130 ppm in the product solution, and the solid dissolution rate can be calculated as 96.66 mg/min, which was 8.9% of the CO\textsubscript{2} dissolution in the bubbling tank. In summary, the dissolution rate of carbonate minerals was relatively slow to the CO\textsubscript{2} dissolution, that means around one tenth of the CO\textsubscript{2} can be really conversed to bicarbonate ions and stored in the solution, the else was temporarily exist in the solution and will be released to the air to be equilibrium with the partial pressure in the atmosphere.

<table>
<thead>
<tr>
<th>weight of solid reactant (g)</th>
<th>Final pH</th>
<th>$\Delta[Ca^{2+}]$ (ppm)</th>
<th>calcium dissolution rate (mg/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>limestone</td>
<td>25</td>
<td>5.85</td>
<td>24.80</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>6.13</td>
<td>108.66</td>
</tr>
<tr>
<td>offcuts</td>
<td>25</td>
<td>6.60</td>
<td>39.59</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>6.66</td>
<td>105.48</td>
</tr>
</tbody>
</table>
In this section, seawater used as the reactant solution had been conducted at the offshore station near Heping Power Plant in the eastern Taiwan on 27 October, 2013. The pH value was 7.63, and the calcium ion concentration was 383.35 ppm. First, the reactant solution had been pumped through the bubbling tank to contact with 100 % \( \text{CO}_2 \), and the pH value decreased to 6.5. This acid solution was further pumped through the fluidized-bed full with carbonate mineral offcuts, and the pH value of the product solution increased to 7.21 due to the dissolution of carbonate minerals. For the \textit{nannochloropsis} cultivation test, the product solution had been mixed with artificial seawater at the ratio of 0%, 25%, 50%, and 100% to see the effects on the \textit{nannochloropsis} growth.

The results have been shown in Fig. 5. The amount of the \textit{nannochloropsis} at the solution with different ratio of product solution ranged from \( 2.5 \times 10^8 \) to \( 3.5 \times 10^8 \), and the standard deviation are in the acceptable region of \( 3.3 \times 10^7 \) to \( 6.3 \times 10^7 \). The amount of \textit{nannochloropsis} shows no significant difference, meaning that the growth condition for the \textit{nannochloropsis} didn’t have sensible variation at different mixing ratio of the product solution, show the product solution might be harmless to the organisms in the ocean.

![Graph showing pH variation and CO2 capture efficiency](image)

**Fig. 4:** The pH variation and the CO2 capture efficiency in the continuous full-system operation. Fixed operating conditions: gas flowrate = 3 L/min, liquid flowrate = 1.5 L/min, 8.33 kg offcut powder, tap water of \([\text{Ca}^{2+}] = 37.66 \text{ ppm}\)

### 3.5 Nannochloropsis Cultivation Test by Using the Product Solution

In this section, seawater used as the reactant solution had been conducted at the off-shore station near Heping Power Plant in the eastern Taiwan on 27 October, 2013. The pH value was 7.63, and the calcium ion concentration was 383.35 ppm. First, the reactant solution had been pumped through the bubbling tank to contact with 100 % \( \text{CO}_2 \), and the pH value decreased to 6.5. This acid solution was further pumped through the fluidized-bed full with carbonate mineral offcuts, and the pH value of the product solution increased to 7.21 due to the dissolution of carbonate minerals. For the \textit{nannochloropsis} cultivation test, the product solution had been mixed with artificial seawater at the ratio of 0%, 25%, 50%, and 100% to see the effects on the \textit{nannochloropsis} growth.

The results have been shown in Fig. 5. The amount of the \textit{nannochloropsis} at the solution with different ratio of product solution ranged from \( 2.5 \times 10^8 \) to \( 3.5 \times 10^8 \), and the standard deviation are in the acceptable region of \( 3.3 \times 10^7 \) to \( 6.3 \times 10^7 \). The amount of \textit{nannochloropsis} shows no significant difference, meaning that the growth condition for the \textit{nannochloropsis} didn’t have sensible variation at different mixing ratio of the product solution, show the product solution might be harmless to the organisms in the ocean.
4. Acknowledgments

The authors wish to express their gratitude to the financial support for the investigation from the Bureau of Energy, Ministry of Economic Affairs. Assistance from the CCS group and encouragement from the management of Green Energy and Environment Research Laboratories, Industrial Technology Research Institute, is also acknowledged.

5. References


Review of Ecological Engineering Solutions for Rural Non-Point Source Water Pollution Control in Hubei Province, China

Min Wu
Key Lab of Basin Water Resource and Eco-Environmental Science in Hubei Province; Changjiang River Scientific Research Institute, China
E-mail address: xiaomai2100@126.com

1. Background/Objectives and Goals
Rural non-point source (RNPS) water pollution control is problematic in Hubei Province, which is a typical agricultural region with abundant rainfall and a developed natural surface water network. The concept of best management practices (BMP) originating from the USA has already been introduced with the aim to reduce the application of chemical fertilizers and pesticides, and water and soil loss. However, a comprehensive evaluation of rural wastewater and nutrient reutilization to benefit the rural communities and the environment has not been attempted.

2. Methods
To fill this gap, this review paper explores the major contributors of RNPS water pollution in Hubei Province, assesses the status of watercourses and discusses the prevalent ecological engineering techniques including vegetated filter strips (VFS), ecological ditches (ED), constructed wetlands (CW), and biogas plants (BP) with respect to aspects such as water purification, energy generation, and nutrient reduction and recirculation.

3. Expected Results/ Conclusions/ Contribution
Findings indicate that RNPS water pollution continuously increased for the past 10 years. Chemical fertilizers, poultry and livestock breeding, aquaculture, and rural living are the major sources of elevated chemical oxygen demand, ammonia–nitrogen, total nitrogen, and total phosphorus loads discharged to receiving watercourses. Finally, ecological engineering technologies such as VFS, ED, CW, and BP are proposed for villages and communities to combat RNPS water pollution. BMP are a promising approach to create a sustainable agricultural system, improve the rural energy consumption structure and living conditions, decrease wastewater discharges, and reduce chemical fertilizer application rate.

Keywords: Agroecosystems; Best management practice; Energy generation; Nitrogen; Phosphorus recycling
Mechanisms of the Phytoremediation of Pentachlorophenol Contaminated Sediment by Aquatic Macrophytes

Liangyuan Zhao
Basin Water Environmental Research Department,
Yangtze River Scientific Research Institute, China
E-mail address: zhaoliangyuannew@163.com

1. Background/Objectives and Goals
Pentachlorophenol (PCP) has been widely used for killing snails, the only intermediate host of schistosome in the middle and lower reaches of Yangtze River where schistosomiasis is epidemic in recent decades. However, the use of molluscicides on large areas has caused the PCP levels exceed environmental standards of sediment in water environment. PCP is a kind of persistent organic pollutants(POPs) and excessive levels of PCP will cause potential threat to the aquatic ecosystem and people's health. The emerging technology of phytoremediation, which has broad applied prospects, is a promising remediation method for PCP treatment thanks to its ecological and economic sustainability.

2. Methods
In the present research, phytoremediation technology was used for pentachlorophenol contaminated sediment and the planting of seven common aquatic plants, *canna indica* L., *acorus calamus*, *alisma orientalis* Juzep, *polygonum hydropipe*, *thalia dealbata*, *iris tectorum*, *cyperus alternifolius* L., was used in this study.

3. Expected Results/Conclusions/Contribution
Seven species of aquatic plants could accelerate the degradation of PCP in sediments, and three aquatic macrophytes, *canna indica* L., *acorus calamus*, *iris tectorum* attained the 98%, 92% and 88% of PCP removal in sediments. Thus, *canna indica* L., *acorus calamus* and *iris tectorum* can be used as efficient alternative plants for remediation of PCP contaminated sediment. In the PCP remediation process, the accumulation of PCP in plant biomass only made a small contribution to the total removal of PCP. Through analysis of pathways of PCP removal, this enhanced dissipation of PCP by macrophyte-microbial association might be mainly the result of aquatic macrophytes-promoted microbial degradation. The PCP metabolites concentrations in rhizosphere sediment and the root tissue of plant showed the trend of 2,4,6-trichlorophenol >2,4-Dichlorophenol> Benzene-1,3-diol>Phenol. In the process of PCP phytoremediation, the number of rhizosphere microorganisms and sediment enzyme activity closely related to PCP degradation rate. The results also indicated that cultivation of aquatic plants can promote the growth of certain microorganisms which changes the original microbial
community structure of sediments, and the microorganism use of sugars, amino acids, esters as the main carbon source increased. The results of this research revealed the phytoremediation mechanism of PCP contaminated sediment by aquatic macrophytes and also can provide scientific basis and application fundamentals for the ecological remediation of PCP in aquatic environment in epidemic areas.

Key words: Pentachlorophenol; Phytoremediation; Microbial remediation; Sediment
1. Background/ Objectives and Goals
Oxide nanomaterials is the focus of the present study. The liquid phase processes of oxide nanomaterials, like the hydrothermal method, the sol-gel method and the micro-emulsion method, have their pros and cons as well. We use the bacteria induced crystallization—an aqueous process that can fabricate nanostructured crystal materials under ambient condition.

2. Methods
We employed the Shewanella strain extracted from the intestines of white-leg shrimps (Litopenaeus vannamei), grown on an aquatic farm in the south of Taiwan. The strain belongs to the same genus as Shewanella oneidensis, identified via the 16S rRNA gene sequence. This strain is not pathogenic: filtered via the human pathogenic gene test. These bacteria make egg-shell like molybdenum bronze material in our experiment.

3. Expected Results/ Conclusion/ Contribution
We have successfully reduced the molybdate and produced metal-oxide materials with egg-shell like shape with nanometer thickness and sub-micrometer diameter. The result is verified by Scanning electron microscope and Energy Dispersive X-ray Spectroscopy. We found that the size of the egg-shell shape material is agree with the sizes of the Shewanella, and the thickness is much less than 100nm therefore can be regarded as nanoscale material.

Keywords: Shewanella, Molybdenum bronze, Bacterially induced crystallization
ICEAI-1103
Research of Ventilation Effects of Atrium Forms in Vernacular Fujian Tulou

Ying-Ming Su*
Department of Architecture, National Taipei University of Technology, Taiwan
E-mail address: ymsu@ntut.edu.tw

Shu-Chen Huang
Department of Architecture, National Taipei University of Technology, Taiwan
E-mail address: moximisty@gmail.com

Abstract
Since global climate changed and urban heat islands (UHI) aggravated rapidly, the energy consumption and the thermal comfort of modern architecture rely upon air-conditioning systems. It is the main focus for urban planning and architectural design to adaptation local climate that causes low energy consumption and Sustainable ecological plan. Researches indicated: Design which emphasizes harmony with the natural environment and adapts in line with local conditions for the vernacular architecture is called "Ecological building". Tulou (or "Earthen buildings") in 2008 was listed on the world heritage (UNESCO). Its design strategy can be applied to modern architecture planning and design. It has thick load-bearing rammed earth walls that can maintain a livable internal environment with warm in winter and cool in summer through appropriate locating of openings and patios. People living in Tulou feel comfortable even without any air-conditioning devices. It is enough to serve as a classic for ecological buildings.

We choose 2 different cases (Double Round Atrium: Zhen-Chen, and Square Atrium: Fu-Yu) of Tulou in Fu-Jian to compare the ventilation effects of different Atrium forms. We adopted field measurements and simulation of temperature, humidity, and wind environment to identify the relationship about external environment and atrium of comfort and confirm the relationship about atrium H/W.

Researches indicate that air flow vortex phenomenon arising from environment of all 3 cases could make wind in the atrium spaces convection. Through the atrium convection effect, it makes that the natural wind guides to each space surrounded and keeps indoor comfort. The comfort of Zhen-Chen (H/W=0.3670) atrium is better than Fu-Yu (H/W =0.8328). It confirms that the lower the ratio of the relationship about atrium comfort with the H/W, the better ventilation efficiency. (Zhen-Chen H/W=0.3670> Fu-Yu H/W =0.8328) The results will be helpful to the application of ecological architecture design in the future.
Keywords: Subtropical, UHI, Vernacular architecture, Atrium, Sustainable design strategies

1. Introduction

Since global climate changed and urban heat islands (UHI) aggravate rapidly, the energy consumption and the thermal comfort of modern architecture rely upon air-conditioning systems. [1] The environmental impact of energy consumption and emissions increased. To solve the problem of environmental damage caused by external effects, in 1992 The United Nations Conference on Environment and Development, UNCED held in Rio de Janeiro proposed sustainable development and sustainability point of view, and gradually rose the concept of ecological building. [2] To investigate the application of the vernacular atrium to a modern high density building has become more important in order to create energy-saving and comfortable environment in subtropical climate area. Vernacular building, the product of hundreds of years of optimization to provide a comfortable shelter in the local climate using available materials and known building techniques, always reflects the obvious apparent characteristics of the indigenous culture and creates a distinctive way of life. [1][3][4][5] In traditional architecture, the courtyard has contributed, even in a passive way, to improve local climate conditions and to create comfortable interior space. Among them, the atrium is a common architectural feature in both modern and historic naturally ventilated building. [6] [7] [8] Serves to enhance the stack pressure driving ventilating flows by providing a tall vertical space in which buoyant air can be accumulated. Significant architectural features such as atrium are often incorporated into building designs in order to assist stack ventilation and thereby deliver a comfortable internal environment. [9] A lot of literature and research confirms: Design emphasizes harmony with the natural environment and on living with local. Reviewed current atrium research projects in Japan, and identified common trends in the design of the indoor thermal environment and the construction of atrium buildings. Based on experimental data, the vertical temperature distribution in an atrium has a huge gradient. Heat stays in the top of the atrium while the bottom temperature is relatively low. The field measurements were conducted to investigate the microclimate in a Chinese traditional vernacular house. [1][10] Wang and Cai evaluated the traditional dwellings through ecological architectural concepts to establish certain advantages of vernacular building in light of a modern environmentally aware evaluation subtropical regions. [11] Tulou is a kind of large-scale civilian residential building which built mainly of rammed earth that distributed across the southeastern China such as Fujian, Jiangxi and Guangdong provinces. It mainly built in a certain scale to meet the needs of the whole clan living together and a sound defensive function. [10] In 2008, the United Nations Educational, Scientific and Cultural Organization (UNESCO) declared 10 Tulou buildings or clusters in Yong-ding County, Nanjing County and Huai-an County as the World Heritage Site.

Research findings found: the air flow vortex phenomenon arising from environment of all 2 cases could make wind in the atrium spaces convection. Through the atrium convection effect,
it makes that the natural wind guides to each space surrounded and keeps indoor comfort.

2. Background of the Case Study

Fujian Tulou appeared in the Tang, Song and Yuan Dynasties and has continued ever after. Since the construction and development process and western Fujian Hakka history and culture are closely related [12], they are mainly distributed in the subtropical climate zone of lower latitudes, and most built in the hilly areas, mountain valley and basin. [13] Because the concept of equality of ethics and group life and other factors and thousand years of history in a strong defense, tulou creates diverse architectural form and space characteristics. In addition, since use the sedimentary soil as construction material, it makes the interior environment warm in winter and cool in summer. It becomes a vernacular architecture of eco-building with elements. [14] Tulou’s main material is constituted by sedimentary soil which is one of the earliest materials being used. Being adapted to the local climate and geographical environment, it is a regional eco-building. (Flg1)

Good ventilation design is the prerequisite of reducing the building energy consumption from the air conditioner, which is known as the most natural construction of energy-efficient practice and the most important to green building climate control Strategy. [15] Air temperature and humidity can adjust the air flow distribution by natural ventilation, and rule out unhealthy indoor air and pollutants, meanwhile make the interior environment warm in winter and cool in summer.

This study is carried out: in the Research of the comfort of the Subtropical vernacular architecture forms with atrium space, we choose 2 different type cases (Double Round: Zhen-Chen, and Square: Fu-Yu) of tulou in Fu-Jian. Focus on promote natural ventilation effect of using the wind guiding at courtyard, with air velocity as the most important factor of environmental comfort.

2.1 Basic Information
The case of Zheng-Cheng Lou and Fu-Yi Lou, both of them, are located in Fu Yu Yong-Ding
County, Fujian Province Hung Village. Zheng-Cheng Lou built in 1912 with double circle form spreads over an area of more than 5000 m². There are 208 rooms inside and outside is the Third Ring Road according to trigram azimuth design (social custom), therefore alias is called more Trigram Lou (show the table 1) Fu-Yu building, an outstanding representative of mansion style at Yong-Ding Tulou. It built in 1882, Wu-Feng form, that spread over an area of more than 7000 m². The passage and rooms constitute six courtyards. There are both a well in left and right sides of the main hall. The cross floor which connect front and main hall is 6 meters tall. And it is a kind of interior bilateral corridor. (Table 1)

<table>
<thead>
<tr>
<th>Architectural style</th>
<th>Zheng-Chen Lou</th>
<th>Fu-Yu Lou</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Double circle</td>
<td>Wu-Feng</td>
</tr>
<tr>
<td>Built</td>
<td>1912</td>
<td>1882</td>
</tr>
<tr>
<td>Located</td>
<td>Fu Yu Yong-Ding County, Fujian Province Hung Village.</td>
<td>Fu Yu Yong-Ding County, Fujian Province Hung Village.</td>
</tr>
<tr>
<td>Coordinates</td>
<td>24° 39' 48.9&quot;N, 116° 58' 25.5&quot;E</td>
<td>24° 40' 3.83&quot;N, 116° 58' 28.01&quot;E</td>
</tr>
<tr>
<td>Alias</td>
<td>Trigram Lou</td>
<td>Representative of mansion style</td>
</tr>
<tr>
<td>Construction area</td>
<td>( \leq 5000 \text{ m}^2 )</td>
<td>( \leq 7000 \text{ m}^2 )</td>
</tr>
<tr>
<td>Building diameter</td>
<td>57.2m</td>
<td>/</td>
</tr>
<tr>
<td>Building height</td>
<td>19m</td>
<td>17m</td>
</tr>
<tr>
<td>Number of floors</td>
<td>4F</td>
<td>5F</td>
</tr>
<tr>
<td>Atrium area</td>
<td>( \leq 600.3 \text{ m}^2 )</td>
<td>( \leq 442 \text{ m}^2 )</td>
</tr>
<tr>
<td>Other atrium quantity</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Building direction</td>
<td>Facing south</td>
<td>Facing northwest</td>
</tr>
</tbody>
</table>

2.2 Spatial Characteristics of Building Microclimate
Within a particular building, a small-scale pattern of “building microclimate” is found that it is different from the microclimate related to the urban fabric scale. In this research, “building microclimate” refers to a type of microclimate involving the indoor space and the spaces
around the indoor spaces of a particular building. The building microclimate is mainly defined by the spatial and the wind environment properties.

The spatial characteristics of a building microclimate regard the following aspects:

- The spatial scale is smaller than the urban fabric. It rarely covers an area more than several hundred meters wide, but is bigger than an indoor space alone. It is limited to one particular building, whether a small house or a big stadium.[1]
- Architecture decisions are typically made at the building scale and design tactics. The atrium spaces are connected with building indoor of every spaces that affect the building microclimate and comfort.
- The existence of diverse types of spaces is another important feature of the building microclimate, which distinguishes it from a single indoor climate. Indoor space, semi-outdoor space and outdoor space are the main spatial types for a building microclimate. Hence corridors, semi-outdoor rooms, courtyards, patios and atria play very important roles in the spatial design to obtain a good building microclimate.[1][15]

### 3. Field Measurements

The subtropical region is the hot-humid climate, including “all Hainan Province, most areas of Guangdong, Fujian and Jiangxi Province, Hong Kong, Macao and Taiwan”. The summer is long and the winter is short in these regions. The summer is hot and humid, and annual average air temperatures are almost higher than 20 °C; in the hottest months, average air temperatures
are above 28 °C, relative humidity is about 80% and the extreme maximum temperatures are about 40 °C. In addition, the winter is warm and humid, average air temperatures in the coldest months are above 10 °C and relative humidity above 70%.[16]

A period of continuous measurements took place in 2013, from 9:00 on November 19th to 09:00 on November 20th and from 9:00 on November 20th to 09:00 on November 21th. Measurements were taken in autumn, the rapid temperature change and low temperature, in key positions at the measured points to measurement of 24 hours. (Fig 4) Experiment data used to compare of different spatial differences were measured at 1.5m height, which will be the range of pedestrian comfort in the wind field as benchmark. Comparison of different spatial differences is performed by observing regulatory of physical environment at Tulou in different periods. In this study, the total velocity magnitude and air temperature of the air were measured by a thermal flow velocity sensor and irrespective of flow direction as well as a relative humidity sensor.

The related accuracies of the values of air velocity magnitude and temperature were within 0.03 m/s and 0.5 °C, respectively, in the measuring ranges of 4-10 m/s and 20 to 70 °C. To avoid the effect of device movement causing airflow disorder, the measuring period lasted 10 min duration with the data recorded 1 second for each measuring point. Moreover, the mean radiation temperature was recorded by a globe sensor (globe diameter is approximately 150 mm) with the accuracy of 0.5 °C. Having all instruments installed on a tripod, the aforesaid probes were connected to a multi-parameter indoor climate meter (Testo 480) for accurate measuring of the flow velocity, temperature and relative humidity (Table 3). Based on the data obtained above, the data will be used to evaluate the high-rise building arcade in autumn wind environment.

Table 3. Measuring instruments and precision introduction.

<table>
<thead>
<tr>
<th>Apparatus</th>
<th>Intention</th>
<th>Label</th>
<th>Error value</th>
</tr>
</thead>
</table>
| AIR VELOCITY               | TESTO 0635              |           | 1. MEASURING RANGES: 0-10 M/S  
2. ACCURACY: ±0.01 M/S ±5% OF MV                                              |
| MEAN RADIATION TEMPERATURE | TESTO 0602              |           | 1. MEASURING RANGES: 0-10 M/S  
2. ACCURACY: ±0.01 M/S ±5% OF MV                                              |
| RELATIVE HUMIDITY          | TESTO 0636              |           | 1. MEASURING RANGES: 20-70 °C, 100% RH  
2. ACCURACY: ±0.1% RH ±0.7 OF MV                                              |
3.1 Field Measurements Data of Atrium Space

Front yard and courtyard in Fu-Yu Lou and Zheng-Cheng Lou. (Fig 5) For the sake of experimental accuracy, the number of the measuring points is increased to 3~7 points for each coordinates. The comparison of measured results of air temperature, relative humidity and wind velocity of the measured vernacular of atrium space Fig 5.

The Zheng-Chen Lou atrium the average temperature ranged from 12.3 to 24.5°C. The average temperature was maintained 21.9°C at morning (9:50am~10:50am), 20.1°C in the afternoon (14:30pm~17:30pm), 15.3°C in the night (19:30pm~20:30pm), 14.8°C in the middle of the night (22:30pm to the next day 3:00am), and 13.3°C in the early morning (4:00am~8:30am). In Fu-Yu Lou, the atrium the average temperature ranged from 11.9 to 23.3°C. The average temperature was maintained 20.7°C At morning (9:00am~10:00am), 20.3°C in the afternoon (13:00pm~17:00pm), 16.3°C in the night (18:00pm~20:00pm), 13.7°C in the middle of the night (22:00pm to the next day 2:00am), and 12.5°C in the early morning (4:00am~8:00am).

The air temperature curves of atrium were comparatively stable at seasonal variations. Due to measuring point (for the construction) was near the main entrance, amplitude changes in wind speed was much various at Zheng-Chen Lou, range from 0.15 to 1.08m/s in the atrium. The Fu-Yu Lou atrium monitored data even at different monitoring points, winds velocity were much consistent, range from 0.2 to 1.1m/s. (Fig 6)
Humidity is the amount of water vapor in the air. Relative humidity (RH) is the ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at the same temperature [17]. Relative humidity depends on temperature and the pressure of the system of interest. Higher humidity reduces the effectiveness of sweating in cooling the body by reducing the rate of evaporation of moisture from the skin. In Fig. 6, it was observed that the relative humidity follows the trend of air temperature during the day. At night, humidity levels mostly exceed 70%. Indoor relative humidity is higher than semi-outdoor relative humidity, which in turn is higher than the outdoor levels measured, whether at night or in the daytime. The higher temperature of outdoor space is due to the lower relative humidity of outdoor space. Besides, high air temperatures have high capacities of accommodating water vapors, and thereby result in better transpiration. In addition to using convection of wind for cooling, the wind of atrium also takes away the moisture in the air, and the measurement of results has low relative humidity. It is clear that the relative humidity is inversely proportional to the air temperature. Moisture in air is highly likely to reduce in high air temperatures; therefore, air convection effectively lowers humidity in the spaces.

In winter, atrium space provided thermal insulation effect. During daytime and nighttime, the air temperature and relative humidity had inverse relationship. The atrium space relative humidity was keep stable within a comfortable range. (Fig 6)
4. Results and Discussion

Atrium is commonly embedded in some buildings for natural ventilation and cooling purposes. Atrium forms center pieces in buildings and connect them to environment by providing natural physical phenomenon of the ventilation and sunlight through exchange of the internal air with the external one [18]. The study show that, regardless of temperature changes, the temperature curve of atrium space is stable. Rajapaksha [19] detailed investigation courtyard advantage utilization in the tropical heat and humid climate. The relationship between courtyard surface temperature and indoor air temperature is a strong correlation, since patio increases ventilation and reduces humidity. The atrium can be used as buffer zone for the ecological design of microclimate to create a comfortable living environment. Atrium space could bring a stack effect to enhance the overall ventilation of indoor air cycling and interior comfort. Wind force drives air in the atrium by increasing the positive pressure exerted on the inlet opening toward atrium. The efficiency of utilizing the wind-driven flow in atrium depends on the interaction between wind and buoyancy ventilation, which results from many factors such as ventilation.
patterns, atrium forms, and opening characteristics. The main advantage of utilization of natural ventilation in building design is not only reducing energy consumption and cost but also providing acceptable comfortable, healthy and productive living environment. The differences of the pressures between the internal and external environments, resulting from factors such as wind and buoyancy driven forces, cause air movement throughout the buildings. [20][21]

- Warm in winter and cool in summer:
Natural ventilation on the one hand can take away the heat of the atrium, on the other hand can increase the body's heat convection and evaporation and can improve thermal comfort. Therefore, well organized natural ventilation is also important means for microclimate regulation. In addition to the heat-resistant in summer should also take into account the heat insulation in winter. The result of this study indicates that there is large difference between the temperatures in the atrium in the summer. The temperature difference between the atrium and the streets have the cooling effect of up to 5℃. Winter temperature difference is small, but the courtyard may be maintained at 18°C -19°C with insulation effect.

- The relationship of the atrium H/W ratio and the physical environment (temperature and wind speed):
Building aspect ratio (H/W) have significant influence on the airflow field inside the atrium. Under certain building height conditions, narrowing building depth and increasing atrium width will increase the exchange of the inside and outside air. It confirms that the higher the ratio of the relationship about atrium comfort with the H/W, the better ventilation efficiency. (Zhen-Chen H/W=0.3670> Fu-Yu H/W =0.8328) The results will be helpful to the application of ecological architecture design in the future.

5. Conclusions
Results show that main Factors influencing wind field convection is caused by the atrium temperature and the surface temperature of the building. Comparing to the use of mechanical ventilation in order to provide a more healthy and comfortable living environment in modern buildings, Tulou becomes the World Heritage which adapts to local geographical conditions efficiently and provides perfect natural ventilation. It guarantees the quality of the building internal environment remained stable and comfortable. Building construction uses huge amount of materials. The employment of local materials in the construction process can reduce transportation energy consumption and environmental impact. According to the ecological environment which is now actively promoting the concept of sustainable development, tulou can self-regulate its micro-climate which can improve its wind field and reduce natural ventilation stagnation discomfort. Façade surrounding the tulou provides a good barrier to prevent the invasion of external wind, and also reduce the temperature difference between day
and night. Even in the cold winter, tulou is still warm enough. Its courtyard design and microclimate regulation proved that regardless the changing of outside wind field, the internal micro-climate of the atrium space is still stable, and maintain human comfort.

6. Acknowledgment
This paper represents part of the results obtained under the support of the National Science Council, Taiwan, ROC (Contract No. NSC104-2221-E-027-096). Thanks for Jia-Hui Lin, Yu-Chou Wu, Zi-Yue Yang, and Yi-Xuan Wu, to assist the research monitoring.

References
Wang Renping, Cai Zhenyu. An ecological assessment of the vernacular architecture and of its
Li Xie, Ya-Fen. “Historical and geographical environment of the formation and development of
Fujian Tulou, Hunan Social Sciences, 2011; 1; 212-215. [PubMed]
Han-Min Huang. Fujian Tulou I , Han Sheng culture. 1994a, Ltd, Taipei.
Ying-Ming Su, Tz-Yue Yang. “A study of Hakka Earthen in the viewpoint od ecological
planning”, Conference on Science, Technology, and society, Hsinchu, Taiwan.
Dayao Li et al. A review of renewable energy applications in buildings in the hot-summer and
warm-winter region of China. [PubMed]
micro-climate on comfort, health and energy demand, Frontiers of Architectural Research.
1(3): 197-228. [PubMed]
Olsen EL, Chen QY. 2003, Energy consumption and comfort analysis for different low-energy
Rajapaksha, H. Nagai, M. Okumiya. 2003, A ventilated courtyard as a passive cooling strategy
Vietnam Ministry of construction.In: Proceeding of the seminar “Effective and economic usage
of energy and resources in building sector”. (Hanoi); 2010. [PubMed]
A.S. Dili, M.A. Naseer, T.Z. Varghese Passive control methods of Kerala traditional
architecture for a comfortable indoor environment: comparative investigation during
various periods of rainy season. [PubMed]
ICEAI-838
Recent Viscosity Data for Al₂O₃ Nanofluids – Behaviour and Stability under Heating Effects

Cong Tam Nguyen
Department of Mechanical Engineering, Université de Monton, Canada
E-mail address: cong.tam.nguyen@umoncton.ca

Marc-André Hachey
Department of Mechanical Engineering, Université de Sherbrooke, Canada
E-mail address: marc.a.hachey@gmail.com

1. Background/ Objectives and Goals
The term ‘nanofluid’ refers to a two-phase mixture of a continuous phase, generally a saturated liquid and of nanometer-size solid particles. Experimental data [1-3] have clearly confirmed the existence of the hysteresis phenomenon for Al₂O₃-water and CuO-water nanofluids when subject to the heating effects. It was found that, depending upon the particle volume fraction, there exists a critical temperature beyond which the suspension quality of the particles can be greatly altered even destroyed, which in turn, may induce an abnormal increase of the nanofluid dynamic viscosity during subsequent cooling and reheating phases. Such a behaviour did raise a very serious concern regarding the nanofluids stability and, consequently, on whether it is worth to use nanofluids for the heat transfer enhancement purpose [2]. In this work, we have experimentally studied two alumina nanofluids (both surfactant-free), namely Al₂O₃-water and Al₂O₃-ethylene glycol with particle volume fractions of 1, 2.5 and 5%. The main objective of our study is to provide new thermal properties data (thermal conductivity and dynamic viscosity) and insight onto the nanofluids behaviour and stability under the heating effects.

2. Methods
In this experimental investigation, the studied fluid (water, ethylene glycol, or nanofluid) was forced inside a thermal-controlled closed circuit in which their thermal conductivity and dynamic viscosity were simultaneously and continuously (i.e. in-situ) measured during three consecutive heating schemes. These heating schemes, or phases, were especially designed in order to determine the nanofluids behaviour under a transient heating (Phase I) as well as to observe the nanofluids stability under a steady-state heating (Phase II); while the reheating Phase III would allow us to study the effect of the hysteresis phenomenon on the nanofluids thermal properties. The nanofluid thermal conductivity measurement was conducted using a hot-wire technique KD2 instrument while the dynamic viscosity was realised using a high accuracy piston-type viscometer.
Measurements were simultaneously carried out though a thermal-isolated chamber where nanofluid was forced in. The nanofluid particle volume fraction has consistently verified prior and after every tests. Tests were also performed to ascertain the repeatability and consistency of the data collected.

3. Results/ Conclusion/ Contribution

The systematic approach to the analysis of nanofluid dynamic viscosity and thermal conductivity brought new correlations and interesting observations to the knowledge of nanofluid thermal properties. The transient heating of nanofluids in Phase I provided some unexpected results: some samples exhibited anomalous behaviour, producing a parabolic variation of the nanofluid thermal conductivity. Some of the datasets did not obey the convention of thermal conductivity being concentration-proportional. Nanofluid dynamic viscosity was found to be more consistent to the theoretical conjecture as its behaviour being primarily characterized by the base fluid with its magnitude dictated by the nanoparticle concentration. The isothermal heating of Phase II successfully enabled a monitored degradation of nanofluid samples. While most samples shown evidence of steady-state degradation, others intriguingly maintained stable rheological and thermal properties. In fact, a subsequent rheological analysis demonstrated that all the tested samples had incurred nanoparticle field degeneration, as number-weighted harmonic mean diameters (NWHMD) and particle size distributions (PSD) were clearly shifted from their respective control groups.

The transient reheating Phase III eloquently confirmed that nanofluid samples have been affected with a permanent modification of properties resulted from Phase II. The dynamic viscosity was found perturbed in all samples, with a magnitude shift from their initial states. Furthermore, the thermal conductivity hysteresis was again found severe with erratic and unusual effects exhibiting sample-specificity. The authors believe that the present data constitute an interesting contribution to the knowledge of the nanofluid thermal stability under heating effects.

Keywords: Alumina-water nanofluid, Alumina-ethylene glycol nanofluid, Thermal conductivity, Dynamic viscosity, Experimental, Heating effects, Hysteresis, Stability,

4. References
ICEAI-989

On the Coupling between the Dynamic Viscosity and Thermal Conductivity for Al₂O₃ Nanofluids – Some Insights onto the Characterisation of Nanofluid Thermal Properties

Cong Tam Nguyen
Faculty of Engineering, Université de Moncton, Canada
cong.tam.nguyen@umoncton.ca

Marc-André Hachey, Nicolas Galanis
Faculty of Engineering, Université de Sherbrooke, Canada
marc.a.hachey@gmail.com

Nicolas Galanis
Faculty of Engineering, Université de Sherbrooke, Canada
Nicolas.galanis@usherbrooke.ca

Catalin Viorel Popa
GRESPI/Thermomécanique, Université de Reims, France
E-mail address: catalin.popa@univ-reims.fr

Abstract
We consider the nanofluid thermal conductivity as a multi-faceted entity which can be resulted from a combination of different heat transfer modes within the nanoparticle-base fluid mixture. These heat transfer modes, derived from the thermo-kinetic and the mesoscopic theories, still constitute subjects for discussion as a consensus has yet been reached among the nanofluids researchers to date. Recent in-house experimental data have shown some new particularities regarding the behaviour of nanofluid thermal conductivity (their variation with respect to the temperature), which indicate that the above heat transfer modes seem to be dependent on temperature but also on the nanofluid apparent dynamic viscosity. Some insights onto the characterisation of nanofluid thermal properties are suggested and discussed in this paper. Experimental results showing the thermal conductivity/dynamic viscosity coupling are presented permitting a complementary discussion regarding this interesting subject.

Keywords: Nanofluid, Alumina-water, Alumina-ethylene glycol, Thermal conductivity, Dynamic viscosity, Experimental, Modelling, Rheology, Brownian motion, Heating effects.

1. Background/ Objectives and Goals
The term ‘nanofluid’ refers to a two-phase mixture of a continuous phase (generally a saturated
liquid) and a discrete phase often composed of metallic nanoparticles. Experimental data have shown that nanofluids may offer a considerable heat transfer enhancement thus can constitute an interesting alternative for thermal applications [1]. It is worth mentioning that there is a striking lack of data for nanofluid thermal properties as well as information regarding their long-term stability and behaviours in real thermal applications [2, 3]. The first studies reported in the literature were mostly concerned with the determination of the nanofluids thermal conductivity. Although some experimental data are available to date, researchers around the world are still searching for a generalised formulation that can be used for the thermal conductivity estimation. The first models, based on the classic Maxwell [4] and Bruggman [5] theory, hereafter referred as EMT (the ‘Effective Medium Theory’) have been found appropriate to this estimation task for some nanofluids reported [6]. It exists however many cases where the measured values of the nanofluid thermal conductivity appear well higher than those predicted by EMT models. Such a departure could be an indication that some heat transfer mechanisms or modes, which have influence on the thermal conductivity of the mixture structure, were not represented in EMT modeling.

One can adopt a more pragmatic approach in modelling the nanofluid thermal conductivity: a nanofluid, by its nature, must be considered as a mobile, stochastic and non-rigid. The existence of the thermal effects described by the Stokes-Einstein’s kinematic theories (known as the particle Brownian movement) was found well justified. Such a formulation has been discussed in 2009 during the International Nanofluid Properties Benchmark Exercise (INPBE) [7] initiated by the Massachusetts Institute of Technology (MIT). Such a benchmark, which necessitated the collaboration of twenty worldwide laboratories using a standardised experimental characterisation of nanofluids thermal conductivity, have come to the conclusion that the thermal effects due to Brownian movement appears non-pertinent to the characterisation of nanofluid thermal conductivity, and EMT models [7] would be sufficient for estimating nanofluid thermal conductivity. We must mention that data provided by INPBE were collected around the ambient temperatures (temperature variation is within few degrees), thus cannot permit a pertinent conclusion regarding the thermal effects inside the particle suspension. In 2014, the authors reported some data for the thermal conductivity and dynamic viscosity of several water and Ethylene Glycol based nanofluids, for different particle volume fractions and temperature varying between 25°C to 55°C. The data collected [8] show some interesting features regarding the variation of the nanofluid thermal conductivity with temperature, and indicate that the dynamic viscosity plays an important role in the characterisation of the particle movement, and hence must be taken into account when modeling the nanofluid thermal conductivity. In fact, any nanofluid thermal property must be seen as dependent on the constituent macroscopic properties but also on the heat transfer modes that exist inside the particle-liquid mixture. The main objective of this paper is to initiate a discussion on the characterisation/interpretation of the nanofluids thermal
conductivity, by recognising the latter as a multifaceted property resulting from the nanoparticle-liquid medium rheological structure.

2. On the Characterisation of Nanofluid Thermal Conductivity

2.1 Nanofluid as a Rigid Medium – the EMT Modeling

Models based on the EMT can be presented in a general formulas as follows (Eq. 1) for a binary mixture:

\[ k_{nf} = k_f \left\{ k_p + k_f + \Phi (k_p + k_f) \right\} / \left\{ 2k_p + k_f - 2 \Phi (k_p + k_f) \right\} \]  

(1)

The nanofluid thermal conductivity is then only function of the macroscopic properties (thermal conductivity) of the constituents (the nanoparticles and the base fluid) and of \( \Phi \), the particle volume fraction. The formulation (1) was found appropriate for very low particle concentrations; otherwise, a severe underestimation of \( k_{nf} \) was confirmed by many researchers. In spite of this, this model as well as many others derived from it, in particular the ones by Maxwell-Garnett [9] and Hamilton-Crosser [10], remain favorite models among nanofluid researchers, likely because of their simplicity [6, 7]. In order to improve the EMT-based models performance, some modifications were introduced to taking into account the interfacial and electrochemical effects of nanoparticles, for example the surface effects (ionised layers) [11-13] as well as effects related to percolation of heat in particle agglomerations [14-16]. Nevertheless, the EMT-based modeling remains an interesting tool to estimate the minimum threshold of the nanofluid thermal conductivity, which theoretically corresponds to the case of a nanofluid where nanoparticles are uniformly and individually dispersed with a minimum rheological interaction between the constituents. Such a case represents in fact a rigid and isotropic medium where conduction is the main heat transfer mode (the classical Fourier’s law).

2.2 Nanofluid as a Mobile Medium

From the EMT principles, we can make abstraction to a mobile medium, for example a binary mixture of a nanofluid, in which stationary elements are homogenously dispersed (just as in a medium of solid elements). A mobile medium possesses different heat transfer modes to which we can truly attribute the amplification observed on the nanofluids thermal conductivity. With these heat transfer modes, temperature effects would result in a certain stochastic mobility on the nanoparticles. This mobility may be due to the Soret effect or of ballistic nature due to the Wiener’s process – a dynamic that is well known under the name of Brownian movement. The difference between the two processes is that the Soret effect exists as long as a temperature gradient exists, and Brownian movement, on the other hand, is related to the absolute temperature in the field. In the perspective of the characterisation of nanofluid thermal conductivity, the Brownian movement appears more pertinent and appropriate.
The particle Brownian movement exists in any solid-fluid mixture and characterises the diffusion of the solid phase by a random excitation of particles. The analysis of the Brownian movement was first introduced by Einstein [17], which conducts, in the context of our discussion, to a definition of the velocity $u$ of a solid element within a liquid medium as follows:

$$u \sim \frac{T}{\mu_f l_c^2}$$  \hspace{1cm} (2)

where $T$ is temperature, $\mu_f$ is fluid dynamic viscosity and $l_c$ is the characteristic length often taken as equal to $d_p$ ($d_p$ is the particle mean diameter). Hence, the nanoparticles of a nanofluid may be mobile in a liquid phase because of their reduced diameters. On the other hand, the shear effect of the liquid molecules around the particles may be sufficient to create the Brownian movement. In either case, such a movement would induce a convective effect between two phases, which may produce favorable effects on the nanofluid thermal conductivity, effects that were not considered in EMT models.

### 2.3 On the Rigid-Mobile Duality of a Nanofluid

The nanofluid is, in reality, a very complex mobile medium because of the particle-fluid base interactions as well as of their very different natures (differences in thermal and physical properties). As we have seen previously, the Brownian movement does always exist within a sufficiently mobile system. The contribution of this movement to the nanofluid thermal conductivity mainly comes from the formation of convective field on nanoparticles. The resulting heat transfer can be characterised by the Nusselt number $Nu$ as follows:

$$Nu = \frac{hL}{k} = A \frac{Re^B Pr^C}{k}$$  \hspace{1cm} (3)

where $L$ and $k$ are the system characteristic length and thermal conductivity; the convective heat transfer coefficient $h$ must be evaluated using empirical constants $A$, $B$ and $C$ adjusted to the Reynolds number $Re$ and the Prandtl number $Pr$. Jang and Choi [18]’s approach proposed the following expression for $h$ as follows:

$$h \sim \frac{k_f}{d_p} \frac{Re^2 Pr^2}{d_p}$$  \hspace{1cm} (4)

where the Reynolds number of the fluid flow over the particle outer surface can be expressed as:

$$Re = \frac{\rho_f d_p u}{\mu_f}$$  \hspace{1cm} (5)

where one can note that the dynamic viscosity (usually of the surrounding liquid) is now
replaced by $\mu_{nf}$ which is in fact the *total or apparent dynamic viscosity* of the nanofluid. This consideration results from an observation of a strong shear effect between the phases, effect that produces an augmentation of nanofluids dynamic viscosity [8]. As such, the total or apparent Prandtl number can be defined as follows to include the total dynamic viscosity (note that the fluid specific heat $c_p$ is still conserved here):

$$Pr = c_p \frac{\mu_{nf}}{k_f}$$  \hfill (6)

By combining the equations (2) and (5), and using the proposed characteristic length $l_c$ as the free path length of fluid molecules, Re becomes as follows:

$$Re \sim \{ (\rho_f d_p T) / (\mu_{nf} l_c^2) \}$$  \hfill (7)

By substitution of Eqs. (6, 7) into Eq. (4), we finally obtain the following form for $h$:

$$h \sim d_p \{(\rho_f T)/(\mu_{nf} l_c^2)\}^2 \{c_p/k_f\}$$  \hfill (8)

We can see from Eq. (8) that both the temperature and the nanofluid dynamic viscosity may play an important role in the convective heat transfer resulted from the Brownian movement. Furthermore, Eq. (8) shows that, as the viscosity as well as other thermal properties are, in general, temperature dependent, then the temperature appears indeed as a key factor in the coupling of the parameters describing the convection field.

The above discussion conducts to the fact that the nanofluid thermal conductivity is indeed a multifaceted property of the mixture. The dominance of heat transfer modes may evolve inside the same domain. Thus, for example, for a highly viscous mixture (due for example to a high dynamic viscosity of the liquid phase, or to a high particle concentration, or in some cases to a particle agglomeration) would not be a favorable medium to rapid particle movements. Such a state corresponds to a stationary one stipulated by EMT models.

3. Results

Fig. 1 shows the coupling between the nanofluid thermal conductivity and dynamic viscosity for Al$_2$O$_3$-EG – 5% v/v nanofluid (the data shown were recently obtained, see [8] for complete details). We notice a parabolic variation of $k$ with respect to temperature. Such a behaviour, somewhat unusual, is believed to be observed for the first time. The same coupling has also been found for two other nanofluids, 2.5% v/v Al$_2$O$_3$-EG, and 5% v/v Al$_2$O$_3$-water.
The parabolic curve presents, in our point of view, at least two dominant heat transfer modes both are temperature dependent: one is shown by $\frac{dk_{nf}}{dT} < 0$ portion in a zone of low temperature, and the other portion with $\frac{dk_{nf}}{dT} > 0$ corresponding to a zone of higher temperature. The $\frac{dk_{nf}}{dT} > 0$ portion qualitatively corresponds to a nanofluid state where the Brownian movement is dominant. In the opposite, the $\frac{dk_{nf}}{dT} < 0$ portion of the parabolic curve may represent a state where another heat transfer mode has predominance effect (while pairing with a considerably high level of nanofluid viscosity). The nature of this additional heat transfer mode remains unknown. We believe that the above parabolic variation of the thermal conductivity would be due to the presence of an important particle agglomeration inside the nanofluid samples tested. Such a particle agglomeration may have aiding effect on the heat percolation within the particle-liquid structure, and can considerably affect the nanofluid dynamic viscosity [20] as well. Such an explanation seems to be plausible based on our laboratory observations of the EG-based nanofluid samples, where a strong particle agglomeration was detected during the stability tests [8].

4. Conclusion
In this paper, based on some recent data for Al$_2$O$_3$ nanofluids, we have presented the coupling between the nanofluid thermal conductivity and dynamic viscosity. It appears that the nanofluid thermal conductivity is a multifaceted entity that depends on several heat transfer modes which may exist inside the particle suspension. The Brownian movement would constitute one possible heat transfer mode, and hence, the nanofluid thermal conductivity could depend on the

![Graph showing thermal conductivity and dynamic viscosity against temperature](image)

*Fig. 1: Composite presentation of $k$ and $\mu$ data for Al$_2$O$_3$-EG – 5% v/v nanofluid (Note: Ethylene Glycol properties were taken from Hagen [19]).*
state of the mobile medium (the base fluid). Both temperature and dynamic viscosity appear then as key parameters in the characterisation of the nanofluid thermal conductivity.

5. Nomenclature

\[
\begin{align*}
C_p & \quad \text{fluid specific heat} & (\text{J/kg K}) \\
d_p & \quad \text{particle diameter} & (\text{m}) \\
h & \quad \text{heat transfer coefficient} & (\text{W/m}^2\text{K}) \\
k & \quad \text{thermal conductivity} & (\text{W/kg K}) \\
l_c & \quad \text{characteristic length (= d_p)} & (\text{m}) \\
T & \quad \text{temperature} & (\text{K}) \\
u & \quad \text{Brownian movement velocity} & (\text{m/s}) \\
\Phi & \quad \text{particle volume fraction} \\
\mu & \quad \text{dynamic viscosity} & (\text{Pa:s}) \\
\rho & \quad \text{density} & (\text{kg/m}^3) \\
\text{Subscript} \\
\text{f} & \quad \text{base fluid, continuous medium} \\
\text{nf} & \quad \text{nanofluid} \\
\text{p} & \quad \text{nanoparticle}
\end{align*}
\]

6. References


ICEAI-1164

Study for the Solar Thermal Collector due to Falling Dust by Numerical Simulation and Experiment

Jiann Lin Chen, Peng Siang Hong
Dept. of Mechanical and Automation Engineering, I-Shou University, Taiwan
E-mail address: james88@isu.edu.tw

1. Objectives

Solar thermal collector has been widely used in absorbing solar energy. However, the effectiveness of the collector will deteriorate due to outdoor falling dust, especially in southern Taiwan for worse air pollution. For this reason, we used the solar simulator to provide the thermal radiation upon the falling-dust sample glass, thereafter the irradiance and temperature on the observation plane were observed. To quantify the effect of falling dust, we employed the computational fluid dynamics (CFD) technique to determine the equivalent irradiance and designed a set of distillers to demonstrate our study.

Keywords: Falling dust, solar simulator, computational fluid dynamics, distiller

2. Methods

To see the effect of falling dust on the performance of the solar collector, we have designed a solar simulator (fig. 1(a)) for analysis. The simulator is made of a halogen lamp and a sample glass covered with falling dust representing the influence of air pollution. Labelled sample glasses were put at a specific location from one day to nine days to collect falling dust for the study. The thermal couple and thermal imager (fig. 1(b)) were used to record the temperature distribution. To quantifying the thermal properties, we used CFD to simulate the thermal-flow field by the light source as the boundary condition (fig. 1(c)) and the thermal radiation was simulated to be reflected upon the observation plane by the reflector (fig. 1(d)). The numerical laminar thermal flow with discrete ordinates radiation model and the SIMPLE algorithm on 0.6 million grids was adopted in CFD. We adjusted manually the diffuse fractions of the simulated glasses to represent falling-dust amount as comparing with simulated and experimental results. Besides, we collected the distilled water to show the feasibility of our research goals based on the sample glasses installed inside the distillers (fig. 2(a) & 2(b)).

3. Results and Conclusion

During the nine-day tests, the hottest temperatures on the observation plane were recorded and the temperature differences compared with the clean glass were calculated. The numerical equivalent irradiances therefore were determined by CFD as validated by the measured temperatures.
Figure 3(a) clearly shows that the hottest temperatures (blue diamond) decline, while the equivalent irradiances (red circle) increase as days go by. Testing by a set of distillers, the irradiance on observation plane decreased 51W/m² and the distilled water decreased 50% for the extreme case if all distillers with their respective sample glasses were exposed to outdoor sunlight for an hour. Figure 3(b) shows that the measured distilled water volumes are decreasing (blue square) and the distillation efficiencies (measurement over theory, which is based on the fundamental energy conservation theory) are approximately 20% (red triangle).

Acknowledgement
Financial assistance for this research provided by the Taiwanese Ministry of Science and Technology, under contract number MOST104-2632-E-214-001, is greatly appreciated.

Figures

Fig. 1 Tools for analysis: (a) the solar simulator, (b) thermal image, (c) numerical thermal flow field, (d) the numerical temperature distribution on the observation plane
Fig. 2 Experiment of the self-made device for making distilled water: (a) design and sketch by CAD, (b) experiment under sunlight for nine sample glasses

Fig. 3 Comparisons of (a) temperature difference obtained from the solar simulator and irradiance by CFD (b) distilled water volume and efficiency by the self-made device
ICEAI-1182
An Application of Maximum Likelihood Estimation in Radiation Portal Monitors

Jiyon Lee
Department of Radiation Safety Research, Korea Institute of Nuclear Safety, Korea
E-mail address: jylee@kins.re.kr

Byoung-Jik Kim
Center for Radiation Analysis, Korea Institute of Nuclear Safety, Korea
E-mail address: k712kbj@kins.re.kr

1. Background/ Objectives and Goals
Two radiation detectors (plastic scintillators and NaI(Tl) types) are widely used in vehicle-based radiation monitoring systems. Plastic scintillators are the most common gamma-ray detectors for portal monitors, mainly due to their relatively low cost of manufacturing for detection over large areas. The NaI(Tl) type is much more expensive, but provides enhanced energy resolution, which enables the spectroscopic identification of some specific radionuclides. To design systems that can be applied to a wide variety of environments, strategic approaches are needed to enhance the technological competence of the two types of detector candidates, and to develop their economic advantages. In this paper, we discuss the development of algorithms for plastic scintillation detectors to identify isotopes during the primary screening step.

2. Methods
Different types of estimation algorithms were applied in the reconstruction of images in positron emission tomography and spectral-deconvolution for enhancing the NaI(Tl) spectrum resolution. For these purposes, the maximum likelihood estimation (MLE) algorithm showed superior performance. In the proposed system, an MLE algorithm was applied for radiation source estimation.

A library of spectral response functions was built up using polyvinyl toluene (PVT) responses to common radiation sources in the laboratory (Cs-137, Co-60, Co-57, radioactive potassium chloride and monazite). A PVT detector (3 x 3 x 2.25 in.) and a 1024-channel MCA were utilized for the measurements. The spectra of unknown radionuclides were measured using a PVT sensor and fed into the proposed MLE algorithm to obtain relative detection probability among the radiation sources of interest. The experiments were designed to answer whether the MLE algorithm could provide additional information, useful for nuclide identification. This study was conceived as a feasibility test and focused on distinguishing Co-60 and K-40.
The spectral response functions of different radionuclides, at low and high energy were indistinguishable. This caused performance degradation, and the count rates of the measured spectrum, in particular, were low compared to those of background spectrum.

The inferential processes were carried out with single and multiple radioactive sources for the input measurements. In fact, a spectrum is compacted by radiation scattering in an RPM operating environment. This distortion will degrade the accuracy of identification. The scattering effect was observed in several thicknesses of a lead plate, as scattering between the radiation source and the detector.

The experiments in the laboratory could not reflect real operational environments such as measurement geometries, and scattering within the container box. Real-scale RPM operations were modeled using the Monte Carlo method. This test assumed a half-filled cargo container with uniform radioactivity, and the amount of radioactivity was varied. The simulated measurements per second were inputted into the inferential process, with background noise. The background was measured in a laboratory, and the size of the scintillator was factored in. A library of spectra was also compiled, being composed of PVT responses to the radiation sources (Cs-137, Cs-134, Co-60, K-40, and Monazite). The radioisotopes of interest included man-made ones of concern for possible transport through ports, and natural ones that are frequently detected. The relative probability of detection of radioactive cesium changed as the ratio of cesium to background counts increased.

3. Expected Results/ Conclusion/ Contribution

Most simulated single radiation sources including Co-60 and radioactive potassium chloride were well identified by the proposed estimation method (Fig. 1). The results showed the potential of MLE applications with plastic scintillators. The inferences correctly indicated the compositions of the multiple radiation sources (Fig. 2).
Using more information in homeland security screening led to the more effective alarms. The alarm level is usually set several percent higher than the background in terms of the count rates; therefore, pre-analysis of the interference from the background would be helpful when attempting to formulate alarm or screening logics. For example, the cargo would pass under the simple alarm condition of 10% of background, while it would be detected if the condition of 30% of relative detection probability were used. An effective level of probabilistic distinction should be predetermined because the criteria in the inspection must be clear. Then, simulations with standardized cargo of one or more types could be expected to optimize monitoring in actual ports.

RPM operation, especially in a port, is a highly complicated task. This is because the technical limits corresponding to various conditions requirements must be understood and the alarm process optimized to accomplish the monitoring goals. The probability distributions as estimation results can provide valuable information that improves the optimization output. Techniques that reduce the triggering of false alarms in plastic-scintillator-based detection
systems will be cost-effective. These methods will be verified in practical applications. Another challenge is expected in determining how best to operate the RPMs.

Keywords: Radiation portal monitor, Plastic Scintillator, Maximum Likelihood Estimation
ICEAI-1218
Thermally Developing Convection Heat Transfer of a Microencapsulated Phase Change Material Suspension through a Partially Heated Circular Tube – An Experimental and Numerical Study

J. B. Huang, C. J. Ho, C. P. Chen
Department of Mechanical Engineering, National Cheng Kung University, Taiwan, ROC
E-mail address: cjho@mail.ncku.edu.tw

Abstract
The forced convection heat transfer problem for laminar thermally developing flow of microencapsulated phase change material (MEPCM) suspension through a partially heated circular tube has been investigated in a combined experimental and numerical approach. Over a finite length of the outer surface, the tube is uniformly heated. The suspension was formulated by dispersing urea-formaldehyde polymer microencapsulated n-eicosane in water, having PCM mass fractions of 2wt.%, 5wt.%, and 10wt.%. The outer wall temperature distribution along and the pressure drop over the tube were measured experimentally. A mixture continuum approach was adopted in the formulation of the energy equation with an approximate enthalpy model describing the phase-change process in the MEPCM particles. Wall conduction along the tube was taken into account in the numerical simulations mimicking the experiments performed. Numerical predictions for outer wall temperature distribution over the partially-heated tube show good agreement with the experimental data. Detailed temperature distributions and heat transfer characteristics for the thermally developing convection of the suspension flows in the tube are elucidated based on the numerical results.

Keywords: Forced convection; MEPCM suspension; Circular tube; Experiment, Numerical simulation

1. Introduction
The interest of using the solid-liquid phase change material (PCM) suspension as the forced convection heat transfer medium in pipe flows is mainly due to its attractive capability of latent heat absorption/release associated with the melting/freezing of the dispersed particles [1-2]. Charunyakorn et al. [3] developed a numerical simulation of laminar forced convection of microencapsulated phase change material (MEPCM) suspension flow in circular tubes with constant wall temperature or constant heat flux and showed a heat transfer enhancement of 2-4 times in comparison with that of pure fluid flow can be achieved. Goel et al. [4] experimentally investigated the laminar forced convection heat transfer characteristics in heating of a suspension containing microencapsulated n-eicosane flowing in a circular tube with constant wall heat flux.
Heat transfer enhancement incorporating the phase change suspension was reported by up to 50% reduction of the wall temperature rise along the heating section. Zhang and Faghri [5] improved the theoretical analysis by taking account of the microcapsules crusts, the initial subcooling, as well as the extended range of phase-change temperature of PCM particles. There exists a substantial disparity between the predicted results [3, 5] and experimental data of Goel et al. [4], which was clarified by Ho et al. [6] to be caused by the wall conduction effect associated with the relatively thick-wall tube used in Goel et al.’s experimental set up [4]. More recently, several experimental works [7-8] concerning laminar heat transfer performance of various MEPCM slurries through a circular tube were reported.

To be a fully viable heat transfer fluid, a fundamental understanding of the convective heat transfer characteristics of MEPCM suspension is definitely required. Detailed experimental measurements and numerical simulations of the temperature field and heat transfer characteristics in a tube of significant wall thickness are particularly essential to acquiring this fundamental understanding. In this context, the heat transfer characteristics of laminar thermally developing forced convection for MEPCM suspension through a partially heated circular tube are investigated both experimentally and numerically. The experimental results are compared with the numerical predictions to assess the suitability of the transport models in depicting the conjugate heat transport phenomena of the PEPCM suspension through a circular tube. From the numerical simulations, detailed descriptions of the temperature field and heat transfer characteristics are then extracted and discussed to provide fundamental insight into the thermal performance of the MEPCM suspension.

2. Experiments

Fig. 1 illustrates schematically the main components of the close loop experimental facility constructed in the present study to supply working fluid to the test tube at the desired pressure, temperature, and flow rate. The working fluid enters the loop from a reservoir through a filter and is continuously circulated by a centrifugal pump. A constant temperature bath installed upstream of the test tube controls the inlet flow temperature. Exiting from the test section, the fluid passes through another constant temperature bath to restore its temperature before returning to the reservoir. Volumetric flow rate inside the loop was monitored by a flow meter. The test section fabricated, which is a circular copper tube with an inner and outer diameter of 3.4 mm and 4.0 mm, respectively. The test section consists of a hydrodynamic entrance section and a heating section. The hydrodynamic entrance section was 0.7 m in length to produce a fully-developed flow entering the heating test section which was 0.4 m in length. The outer surface of the heating test section was wrapped with an equally spaced winding of insulated copper wire along the axial direction of the copper tube, which was connected to a DC power supply to provide constant heat rate to the outer surface of the test section. The power supplied was determined using the measured voltage and current supplied to the heating wire.
A Bakelite tube with an inner diameter of 6 mm was positioned co-axially to provide rigidity of the whole test section assembly. To further minimize the heat loss, the test section was wrapped with foam insulation layer of 1 cm in thickness. The temperatures on the outer surface of the test section were measured ten T-type thermocouples along the axial direction. All thermocouples were calibrated against a standard thermometer. Two RTDs and pressure taps were positioned to measure the temperature rise and pressure drop across the test section, respectively.

In preparation of microencapsulated phase change material (MEPCM) suspension, interfacial polycondensation together with emulsion technique [9] were adopted. The core phase change material (PCM) in the MEPCM particles is n-eicosane which was emulsified in water-soluble urea-formaldehyde per-polymer solution without deliberately added emulsifier. The PCM made up about 60 wt.% of a MEMPCM particle. The MEPCM suspension was formulated by mixing appropriate quantities of MEPCM particles with ultra-pure Milli-Q water (the base fluid) in a flask and then dispersing in an ultrasonic vibration bath for at least 2 hours. Three mass fractions of PCM (ω = 2, 5, and 10 wt.%) of the suspension, which was determined by using a differential scanning calorimeter (DSC), were formulated for the present experiment. The volume-averaged size of the MEPCM particles in the suspension formulated was determined by means of a laser diffraction technique to be in the range of 4 ~ 10 μm.
In the present study, forced convection heat transfer experiments have been undertaken for the horizontal tube using the pure water ($\omega = 0$ wt.%) or the MEPCM suspensions ($\omega = 2$, 5, and 10 wt.%) as the working fluid under the following operating conditions: the volume flow rate $Q = 60 \sim 240$ cm$^3$/min (the Reynolds number $Re_f = 513.6 \sim 1801.3$), the heating power applied at the outer wall of the tube $q_o = 20$, 30, 40 W, and the inlet temperature $T_{in} = 32.8 \sim 33.2^\circ$C.

Uncertainties in the measured quantities for the present study were estimated to be $\pm 0.3^\circ$C in the temperature, $\pm 3.5 \sim 5.0\%$ in the measured power input, $\pm 0.4 \sim 1.2\%$ in the flow rate, and $\pm 0.075$Pa in the pressure drop. Following the uncertainty propagation analysis, the uncertainties for the deducted experimental results were estimated as follows: $\pm 4.2 \sim 6.8\%$ for the dimensionless wall temperature, $\pm 0.4 \sim 1.2\%$ for the Peclet number, and $\pm 3.85 \sim 5.84\%$ for the friction factor, respectively.

2. Numerical Simulation

Numerical simulations were undertaken mimicking the experiments for the thermally developing forced convection of MEPCM suspension flow through a circular tube of inner radius of $r_i^+$. Over an axial length of $l_o^+ (0 \leq x^+ \leq l_o^+)$, as depicted schematically in Fig. 2, the outer surface of the tube wall is heated uniformly by a constant heat flux $q_o^+$. The upstream side of the tube is sufficiently long so that the suspension flows through the pipe with a fully developed laminar velocity profile. The encapsulated PCMs in the suspension can undergo solid-liquid phase change so that they can be solid, liquid, or both.

![Fig. 2 Schematic diagram of physical configuration and coordinate system.](image)

Utilizing the mixture continuum formulation described in the references [6, 11], the energy equation for the MEPCM suspension flow in the tube can be formulated in the cylindrical coordinates as
\[ \frac{\partial T}{\partial t} + u^* \frac{\partial T}{\partial x} = \alpha_\varepsilon \left[ \frac{1}{r^*} \frac{\partial}{\partial r^*} \left( r^* \frac{\partial T}{\partial r^*} \right) + \frac{\partial^2 T}{\partial x^2} \right] - \left( \frac{\varphi \lambda_{sh}}{c_p} \right) \frac{\partial \xi_i}{\partial t} + u^* \frac{\partial \xi_i}{\partial x} \]  

(1)

where the velocity profile is \( u^* = 2u^* \left[ 1 - (r^* / r_i^*)^2 \right] \) and \( \xi_i \) denotes the liquid phase fraction in the MEPCM particles of the suspension. In the derivation of Eq. (1), several simplifying assumptions were incorporated: (a) the particles are rigid spheres of homogeneous size that is sufficiently small compared with the characteristic dimension of flow; (b) the suspension is dilute, homogeneous with a mass fraction \( \omega \) and is considered as Newtonian fluid; (c) the dispersed particles are neutrally buoyant in the suspension fluid; (d) the flow is assumed to be laminar, incompressible, and axisymmetric; (e) local thermodynamic equilibrium is assumed except during the solid-liquid phase change process in the particles; (f) density change associated with solid-liquid phase change in the particles is neglected; (g) all physical properties of the suspension are constants and viscous dissipation in the flow is neglected.

Moreover, the second bracket on the right-hand side of Eq. (1) represents the latent heat transport associated with the solid-liquid phase change in the particles of the suspension flow.

For closure, the liquid fraction of the MEPCM particles, \( \xi_i \), in Eq. (1) is evaluated adopting an approximate enthalpy formulation by

\[ \frac{\partial \xi_i}{\partial t} + u^* \frac{\partial \xi_i}{\partial x} = \left( \frac{A_p U}{\rho_s \mathcal{H}_{f} \varphi} \right) (T - T_w) \]  

(2)

Here the assumptions of negligible supercooling and neglecting thermal inertia of the phase change have been adopted.

In view of the fact that the copper tube used in the experimental setup has a significant wall thickness compared to its inner diameter, \( \frac{t_w^*}{r_i^*} = 0.176 \), the axial wall conduction effect could be appreciable [6] and thereby was taken into account by considering the conduction heat transfer equation for the tube wall as

\[ \frac{\partial T}{\partial t} = \alpha_t \left[ \frac{1}{r^*} \frac{\partial}{\partial r^*} \left( r^* \frac{\partial T}{\partial r^*} \right) + \frac{\partial^2 T}{\partial x^2} \right] \]  

(3)

From the foregoing formulation for the geometrical dimensions of the experimental set-up, the relevant dimensionless physical parameters for the present simulation include the mass fraction of PCM in the suspension, \( \omega \), the Peclet number, \( Pe_f \); the Stefan number, \( Ste_f \); and the
dimensionless inlet temperature, $\theta_{in}$, and the thermophysical property properties ratios of the suspension to the base fluid or tube wall. The dimensionless bulk temperature $\theta_b$ and the mean liquid fraction of MEPCM in the suspension $\xi_b$ are defined, respectively, as

$$\theta_3 = \frac{1}{r_{in}} \int_{r_{in}}^{1} ur\theta dr \int_{r_{in}}^{1} ur\theta dr$$

(4)

$$\xi_3 = \frac{1}{r_{in}} \int_{r_{in}}^{1} ur\xi dr \int_{r_{in}}^{1} ur\xi dr$$

(5)

**Numerical Method**

The steady state solutions to the dimensional governing equations were numerically obtained via the pseudo-transient finite difference method. The convective terms in the differential equations were approximated by the QUICK scheme while the diffusion terms by a second-order central difference scheme. The systems of algebraic discretization equations obtained for the energy equations and the liquid fraction equation were, respectively, solved by the line-by-line application of the tri-diagonal matrix algorithm and the point iteration. The temperature field was considered convergent when the maximum variation between the values of computed and previous iteration is less than $10^{-6}$. All computations were performed with double-precision arithmetic. From extensive grid-size convergence tests, simulation results shown later have been obtained for several meshes ranging from 121 (radial direction) x 801 (axial direction) to 821 x 1201, depending mainly on the Peclet number $Pe_f$ and the PCM mass fraction $\omega$. Of the grid points in the radial direction, at least 21 were laid within the thickness of tube wall.

**3. Results and Discussion**

The measured data for the wall temperature distribution along the outer surface of tube under various sets of flow conditions are first compared with the corresponding numerical predictions to validate the numerical accuracy of the conjugate heat transfer model adopted. Then, the temperature distributions and the heat transfer characteristics of the thermally developing convection of MEPCM suspension through the partially-heated tube are described in detail based on the numerical results. The measured temperature distribution along the outer wall of tube is presented by the dimensionless temperature difference $\theta_{w,o} - \theta_{in}$ and compared with the predicted results from the corresponding numerical simulations, as exemplified in Figs. 3-4 for the volume flow rates of 60 and 240 cm$^3$/min, respectively.
Common to the data displayed in the figures is that before reaching the exit of heated section, the convex rise of outer wall temperature along the flow direction arrests and gives way to a drastic decline all the way through the downstream adiabatic section, indicative clearly of occurrence of post-heating over the non-directly heating wall due to the axial wall conduction. Based on the experimental results shown in Fig. 3, it is clear that with increasing PCM mass fraction in the suspension, the maximum outer wall temperature becomes increasingly lower and thus the wall temperature rise over the heated section appears significantly reduced, reflecting the efficacy of latent-heat absorption associated with using MEPCM suspension for temperature control/thermal management application. Specifically, a reduction of more than 17% in the outer wall temperature rise over the heated section was observed for the suspension of 10 wt.% at the flow rate of 60 cm$^3$/min compared with that for the pure water. Moreover, the flow rate as well as the PCM fraction of the suspension can have strong bearing on its efficacy in suppressing wall temperature rise over a tube heated at a given power. As can be discerned from a comparison between Fig. 4 and Fig. 3, with an increase of flow rate of the suspension, the residence time and hence, in effect, the melting progress of the particles over the heated section can be significantly retarded, resulting in markedly higher wall temperature rise; which becomes further distinctive with increasing PCM mass fraction. In particular, with the flow rate increased up to 240 cm$^3$/min in the tube heated at 20W, the efficacy of wall temperature

![Graph showing temperature distribution](image)

Fig. 3 Comparison of experimental data and numerical predictions for (a) outer and (b) inner wall temperature distributions along the tube heated by different power at the volumetric flow rate of 60 cm$^3$/min.
suppression appears nearly diminished for the suspension containing the largest PCM fraction of 10 wt.%. It follows that there may exist an optimum flow rate for a suspension containing given PCM fraction in the tube heated at a fixed power, under which the maximum reduction in the wall temperature rise over the heated section arises. More importantly, it is evident that there exists good agreement between the predicted and measured outer wall temperatures through the length of tube tested, thus validating the numerical simulations.

![Graph showing temperature distribution](image)

**Fig. 4.** Comparison of experimental data and numerical predictions for (a) outer and (b) inner wall temperature distributions along the tube heated by different power at the volumetric flow rate of 240 cm³/min.

Also included in Figs. 3-4 are the results for the inner wall temperature estimated from measured outer wall temperature and predicted numerically. As may be anticipated, there generally exists minute temperature drop across the wall thickness of the copper tube used; and thus the inner wall temperature estimated or predicted exhibits a similar axial variation to that of the outer wall temperature. Closer examination of Figs. 3-4 reveals that over the downstream adiabatic region following the heated section, the inner wall temperature remains above the melting temperature of PCM and thus the melting progress of particles is expected to further proceed. Moreover, in the presence of axial wall conduction, the estimated inner wall temperature may markedly deviate from that predicated numerically; in particular, in the region near the exit of heated section under the lowest flow rate of 60 cm³/min.
Having validated the numerical predictions, the more detailed depictions of the thermally developing convection heat transfer characteristics of the MEPCM suspension flow in the tube are now discussed. The axial distributions of the temperature difference, $\theta_b-\theta_m$, and mean melted fraction, $\bar{\xi}_b$, as illustrated in Fig. 5, for flow rate of $Q = 60 \text{ cm}^3/\text{min}$ in the tube heated by various powers, the axial variation of bulk temperature for the suspension over the heated section can be seen to gradually deviate downward from the linear rising curve expected for the pure water, yielding marked reduction in the bulk temperature rise for the suspension compared with that for the pure water. The reduction in the bulk temperature rise of the suspension is evidently resulted from the latent-heat absorption due to the melting progress of particles over the heated section, as depicted by the curves of the mean melted fraction $\bar{\xi}_b$. The capability of reducing bulk temperature rise by the suspension can be distinctively promoted with an increase of the PCM mass fraction; as a result, the suspension containing 10 wt.% of PCM yields the smallest rise of the bulk temperature over the heated section.
In contrast, with an increase of the flow rate up to 240 cm$^3$/min, the intensified flow and thus the enhanced convective transport of sensible heat, respectively, give rise to considerable reduction in the residence time of the particles and the inner wall temperature over the heated section. Consequently, the melting progress of the particles becomes significantly impeded, resulting in appreciably lower melted fraction and higher bulk temperature at the exit of heated section as shown in Figure 6. As indicated by the curves for the mean melted fraction in Fig. 6, the particle melting continues to progress, depending on the PCM fraction and flow rate; and the ongoing latent-heat absorption results in a rather drastic decline of the bulk temperature for the suspension along the downstream adiabatic region following the heated section, where in contrast, the bulk temperature for the pure water remains essentially unchanged. Above all, for the flow conditions tested, the MEPCM particles are predicted to remain incompletely-melted at the outlet of tube considered.

5. Concluding Remarks

The heat transfer characteristics of thermally developing convection of MEPCM suspension in a partially heated circular tube have been investigated both experimentally and numerically. The accuracy of the numerical simulations mimicking the experimental configurations was first assessed against experimental data for the outer wall temperature of the tube. The results from the numerical simulations were then used to explore the detailed temperature distributions and conjugate heat transfer characteristics of the suspension flow in the tube. For the flow
conditions tested, significant post-heating over the non-directly heated downstream region of the tube due to axial wall conduction has been identified experimentally and numerically. The wall temperature control efficacy of incorporating MEPCM suspension in the tube heated at a fixed power strongly depends on the flow rate and PCM mass fraction, underscoring the possibility of existing an optimum flow rate for a suspension of given PCM fraction yielding the maximum reduction in the wall temperature rise. Compared with water, the suspension containing 10wt.% PCM at the lowest flow rate of 60 cm$^3$/min shows the largest reduction of 17% in wall temperature rise over the heated section of the tube heated at 20W. Moreover, the efficacy of wall temperature reduction found for the suspension flows tested appears rather outweighed by the much greater increase of up to 50% in the friction factor measured. For feasible application of using MEPCM suspension, efforts on exploring effective means of reducing the dynamic viscosity while enhancing thermal conductivity of the MEPCM suspension should therefore be focused in the future study.

Acknowledgement
The present study was supported by Ministry of Science and Technology (MOST) of ROC in Taiwan under Project No. MOST103-2221-E006-222-MY3.

6. References


ICEAI-1225
The Investigation of Charge Transport Behavior of Ionic Liquid/PVDF-HFP Electrolyte with Propylene Carbonate Solvent

Jun-Hong Lin*, Zhao-Cheng Chen, Bo-Wen Shi
Department of Mold and Die Engineering,
National Kaohsiung University of Applied Sciences, Taiwan, R.O.C
E-mail address: Jhin@kuas.edu.tw

Abstract
Ionic liquid/PVDF-HFP based electrolyte is one of the promising solid state electrolyte for energy storage devices. It is known that additional amount of propylene carbonate (PC) can improve the conductivity of the electrolyte though the ion concentration is diluted. Both dielectric spectroscopy and time domain method are employed to characterize the segmental dynamics of the polymer matrix and the charge dynamics of ionic in the electrolyte over a broad temperature range. It is found the both conductivity and mobility of the electrolyte are improved due to the acceleration of the PVDF-HFP chains. Also the mobile ion concentration was of the sample with PC is higher than that without PC solvent even the total ion concentration of the ionic liquid salt is diluted.

Keywords: electrolyte, ionic liquid, conductivity, mobility, ion concentration

1. Background
Ion transport and storage in solid state polymer matrix films is of great interest for energy storage devices and transducers, such as actuators, sensors, fuel cells, and supercapacitors [1-5]. Under electric field, ions with opposite polarity are transported through the polymer membrane, and the accumulation of ions near the two electrodes results in the charge storage and the electroactive strain of these electroactive devices[6]. Despite the huge practical importance of ionic liquid containing membranes, after decades of research, many aspects of ion transport of ionic liquids in the polymer matrix are not fully understood.

Room temperature ILs are a class of salts composed of large cations and anions in liquid form at room temperature, and are highly advantageous compared with aqueous electrolytes because of their prominent properties, including high ionic conductivity, negligible vapor pressure, broad electrochemical window, and high thermal stability[7]. It has been demonstrated that compared with aqueous solutions, the use of ILs as electrolyte can increase the life time of the electroactive devices dramatically. Furthermore, their broad electrochemical windows allow for higher applied voltages. Among various ILs, EMI-TFSI is one of the ideal ILs for energy storage devices because of its high conductivity, low viscosity, and large electrochemical...
Poly(vinylidene fluoride-co-hexafluoropropylene) PVDF-HFP consists of poly(vinylidene fluoride) main chains and hexafluoropropylene side chains and is well known for its chemical inert properties and is compatible with various kinds of ionic liquid electrolytes which make it suitable for the polymer matrix for solid state electrolyte[8]. The dielectric behavior in response to AC stimuli of PVDF-HFP have been intensively investigated by impedance approach. The relaxation peak at low frequency is usually referred to the long range segmental relaxation of the main chains while that at higher frequency is usually referred to the shorter range relaxation of the side chains. When blended with ionic liquid, the conductivity of the electrolyte is decrease dramatically when compared to that of the neat ionic liquid. One of the effective way to improve the conductivity of the solid state electrolyte composted is to have additional solvent into composite. Propylene carbonate (PC) melting point ~48.8 °C and Ethylene carbonate (EC), MP~34 °C, are commonly used solvents and it have been found that with additional amount of solvent in the ionic system the conductivity of the electrolytes increase dramatically. However, the charge transport mechanism is not clear yet.

Here we employ the impedance approach, to estimate how the ionic liquid and solvent affect the polymer chain relaxation behavior and hence the ion conductivity of the solid electrolyte composites. On the other hand, the conductivity, mobility and mobile ion concentration of the composite was also estimated by a newly developed time domain model[6]. Based on the modified Poisson-Nernst-Planck relation, the conductivity can be separated into the contribution of mobility and mobile ion concentration. In this work, ion conduction occurs in the polymer matrix, it is inevitable to exam the correlation between the ionic conduction and the segmental dynamics of the polymer chains. Here, we explore the dielectric spectroscopy as well as transient current responses of the EMI-TFSI/PVDF-HFP membranes with different solvent over a broad temperature range to investigate the how the ion transport behavior of ionic liquid was affected by the solvent.

2. Methods

Sample Preparation
PVDF-HFP, EMI-TFSI and Propylene carbonate are purchased from Aldrich. PVDF-HFP and EMI-TFSI are dried in vacuum oven at 80 C for 12 hrs before process. 400mg of PVDF-HFP are dissolved in 3 ml acetone solvent and stirred for at least 4 hrs. After the polymer is dissolved in acetone, 280mg of ionic liquid EMI-TFSI was then added and stirred for another 2 hrs. For the sample with PC solvent, an amount of 350mg additional PC was added. The solution was casted in a Teflon coated glass to from the PVDF-HFP/EMI-TFSI and PVDF-HFP/EMI-TFSI/PC composite films. The thickness of these samples are at around 50 microns. For the electrical measurement, gold leaf are employed as electrodes on both side of
the membranes.

**Measurement Methods**

In general, charge transport is a result of drift and diffusion and can be described by Poisson-Nernst-Planck equations[6],

\[
\frac{\partial \rho}{\partial t} = \nabla \cdot (\rho \mathbf{J}) = \rho \nabla \cdot \eta \nabla \phi
\]

\[
\mathbf{J} = -\eta \nabla \phi + \rho \mathbf{E}
\]

where \( \rho \) is the charge concentration, \( \mathcal{E} \) the dielectric constant of the medium, \( \mathcal{E} \) the vacuum permittivity, \( \phi \) is the electric potential, \( \eta \) is the conductance, \( \mathbf{E} \) the electric field, \( D \) the diffusion coefficient. For the ionic liquids studied here, we assume \( n_+ = n_- \) and \( D \) are related by the Einstein equation, \( D = \mu K T / q \cdot [6] \)

![Diagram](a) \left( \begin{array}{c}
\text{Potential}
\end{array} \right)

(b)

Figure 2-1 the plot shows the charge process of electric double layer capacitors

For the ionomer membrane in figure 2-1(a) under a step voltage (from 0 at \( t<0 \) to \( V \) volts at \( t>0 \)), the initial current density before the screening of electric field occurs is \( I_0 = \frac{V}{S/d} \), where \( (\approx qn) \) is the conductivity, \( d \) is the membrane thickness, and \( S \) is the electrode area. When the applied voltage is not high (in the order of \( 10kT \), where \( k \) is the Boltzmann’s constant), the initial transient current follows the charging of an electric double layer capacitor \( C_D \) in series with a bulk resistor \( R \), [6]

\[
I(t) = I_0 \exp \left( -\frac{t}{\tau_{DL}} \right)
\]

where \( \tau_{DL} = d \quad \text{DL}/2D = RC_D \), describes the typical charging time for the electric double layer.
which has a thickness $\lambda_{DL}$, the Debye length,

$$\lambda_{DL} = (\varepsilon \varepsilon_0 kT / Z^2 q^2 n)^{1/2} \quad (4)$$

where $Z$ is the mobile ion charge ($=1$ for EMI-Tf), and $q=e$, electron charge. It was further shown that at longer time, the charge diffusion from the bulk to the double layer region leads to a power law decay of the diffusion current (in which the initial current fits well by eq. (3), followed by a power law decay of the diffusion current, having a typical time constant $\sim d^2/(4D)$). Therefore, by fitting experimental transient current $I(t)$ with eq. (3), $n$, and can be obtained if of the ionomer membrane (with ILs) is known, [6]

$$\sigma = \frac{I_0 d}{VS} \quad \mu = \frac{qVS\varepsilon_0 d}{4kT\lambda_{DL}^2 I_0} \quad \eta = \frac{4kT\lambda_{DL}^2 I_0^2}{\varepsilon_0 q^2 V^2 S^2}$$

Impedance spectroscopy is employed to determine $\lambda_{DL}$. Besides $n$ (=$d/(SR)$, where $d$ is the thickness and $S$ the surface area of the membrane), can also be determined from the Nyquist plot.

### 3. Results

Figure 3-1 plots the dielectric relaxation loss peak of PVDF-HFP with EMI-TFSI over a broad temperature from -40 to 80 °C. As can be seen, the relaxation peak at -30 °C (the black square symbol) is at ~10 Hz and that at 30 °C (pink star) is at ~4kHz. Above 30 °C the relaxation peak did not move forward further with increasing temperature. This means that the peak represents the relaxation frequency of the HFP side chains shit to high frequency progressively from ~10 Hz to the highest frequency and gradually saturate with temperature at an ultimately frequency at $3\times10^3$ Hz. Above that frequency, the relaxation frequency is approximately fixed and did not increase further with increasing temperature.
Figure 3-2 plots the dielectric loss response of the PVDF-HFP/EMI-TFSI with additional solvent PC. The result indicated that the relaxation peak at low temperature -30 °C is at ~500Hz while that at 10 °C is at ~3kHz and above which the frequency is almost identical. This indicated that the similar phenomena as that observed at figure 3-1, that is the relaxation peak frequency increases with increasing temperature. However, when compared to figure 3-1, the relaxation frequency of the sample with PC at -30 °C (500 Hz) is much higher than that sample without PC solvent at the same temperature. This result implies that the additional of PC solvent accelerate the segmental motion of the HFP side chains and this could provide the reasonable clue to answer the question why the conductivity of the sample with PC is much higher than that without PC over all the measured temperature range.

On the other, it seems that the saturation of relaxation frequency of both samples is almost the same but the one without PC solvent saturated at 40C and that without PC saturated at 10 °C. This implies that though at the same temperature, solvent PC accelerate the relaxation frequency of the PVDF-HFP side chains, it does not change the ultimate relaxation frequency of the chains much.
Figure 3-2 The dielectric relaxation loss of PVDF-HFP/EMI-TFSI.

Figure 3-3 plots the conductivity versus temperature of the samples. As can be seen the temperature dependent behavior of these two samples follows the VFT relation well (fitted solid line) implying that the ionic conduction in these two samples is coupled to the segmental motion of the polymer chains. (The solid line represent the fitting to the VFT relation.)

Obviously, the sample with PC solvent has a much higher conductivity over the temperature range, though the sample was diluted by the PC solvent. On the other hand, a sudden drop of conductivity was observed at 246 K for the PVDF-HFP composite. This dramatic decrease on conductivity might be attributed to the solidify process of the EMI-TFSI near the same temperature. On the other hand, in the sample with PC, the sudden decrease on conductivity was not observed even at the lowest measured temperature (243K) implying that the EMI-TFSI did not solidify due to the additional PC solvent. Therefore, it is not surprise that the sample with PC has a one order higher conductivity than that without PC solvent. To reveal the fundamentals beneath the increased conductivity, we employed the time domain model to separate the conductivity into the contribution of mobility and mobile ion concentration.
Figure 3-4 represents the ion mobility of the PVDF-HFP/EMI-TFSI samples with and without PC solvent. The nonlinear temperature dependent behavior implying that the ion mobility is coupled to the segmental motion of the PVDF-HFP chains. A sudden drop on mobility is also observed on ion mobility at 240 K indicating the solidification of the EMI-TFSI salt in the PVDF-HFP matrix. On the contrary, the mobility drop is not observed on the sample with PC over the measured temperature range. This may be due to that the PC solvent help the dissociation of the EMI-TFSI salt and keep it from solidification at low temperature range. On the other hand, the mobility of the sample without PC drop dramatically at high temperature range while the data of the sample with PC was not plotted due to the consideration of the evaporation of solvent PC at high temperature region which might affect the PC content in the sample.
Figure 3-4 The ion mobility versus temperature for PVDF-HFP/EMI-TFSI with and without PC solvent.

Figure 3-5 plots the mobile ion concentration of the both composites. The one without PC solvent has a higher mobile ion concentration than that without PC solvent even the sample was diluted by the PC. This implies that the PC assistant the dissociation of the ions in the composted. As can be seen, the concentration of the sample without PC drop at ~240K as the solidification of the EMI-TFSI. While the above 320°C the slop of the temperature dependence of concentration increases, this may be the reason that the temperature dependence of mobility decrees with increasing temperature at the high temperature region. As the mobile ion concentration is high at high temperature, the probability for ions to collide each other increases and thus reduces the ion mobility as shown in figure 3-4.

Figure 3-5 The mobile ion concentration versus temperature for PVDF-HFP/EMI-TFSI with and without PC solvent.

4. Conclusion
Ionic liquid based PVDF-HFP solid state electrolyte was investigated. It is found that with additional amount of solvent PC the conductivity of the electrolyte can be improved. The conductivity was separated into the contribution of mobility and mobile ion concentration. The dielectric spectroscopy results indicated that the segmental relaxation frequency is accelerated by the additional amount of PC solvent. Besides, the mobility of the mobile ions was also increased due the existence of PC solvent at the same temperature. Moreover, even was diluted, the mobile ion concentration of the electrolyte with additional solvent was higher than that without solvent.

Acknowledgments
The authors would like to thank the Ministry of Science and Technology, R. O. C., Taiwan, for the funding support under Grant MOST 104-2221-E-151-039.

References
ICEAI-1232
Using AHU Outdoor Air Demand Control and VAV for Energy-Saving and Indoor Air Quality

Yu Lieh-Wu*, Jian-An Chen, Kun-Hua Lyu, Jun-Tsuo Chiu and Yu-Chien Lin
Department of Refrigeration, Air-Conditioning and Energy Engineering,
National Chin-Yi University of Technology, Taiwan
wuyl@ncut.edu.tw

Abstract
This study analyzed the energy-saving benefit of air-handling unit outside air demand optimization control and air-handling unit (AHU) system air supply zone with variable air volume (VAV) variable frequency system by actual improvement and measurement. Meeting the Indoor Air Quality Management Act and indoor air conditioning preset temperature requirement, the supervisory control computer adjusts 10%~100% air-handling unit outside air damper opening and the 30Hz~60Hz fan motor speed automatically, so as to improve the air conditioning energy consumption of outside air load and to adjust the air conditioning air output in off duty time intervals to reduce the energy consumption of motor operating load.

Two control modes are compared in this study: Model 1: the traditional manually controlled outside air damper opening is fixed 100%, changed to adjusting outside air damper opening to 10%~100% automatically by detecting indoor CO2 value and matching outdoor enthalpy; control mode 2: mounting regional variable air volume systems and mounting frequency converter on fan motor to improve the energy consumption of air-handling unit air supply motor. The supervisory control computer records the indoor CO2 value, outside air damper opening, outside air enthalpy and fan motor operating frequency values. The statistical analysis shows control mode 1 improves the outside air load energy consumption of outside air demand control individually, the energy-saving rate is 78%, the total amount of energy saving is 21.2%.

The control mode 2 creates outside air demand control and fan motor variable frequency, the energy-saving rate is: (1) 82.1% of outside air load energy consumption of outside air demand control; (2) 42.2% of fan motor variable frequency, the actual total amount of energy saving is as high as 51.2%. Therefore, the combination of air-handling unit outside air demand control and VAV variable frequency control system is of great help to the energy saving of air-handling unit system and provide equivalent IAQ.

Keywords: Outdoor air demand control, Variable frequency control, Indoor air quality, Outdoor air enthalpy
Poster Session (6)

Information Engineering/ Electrical Engineering (2)/

Industrial Engineering/ Civil Engineering/

Mechanical Engineering

Thursday, May 12, 2016 13:30-14:30 Room 1008

ICEAI-945
Locating Nipple in a Volume of Transverse Breast MR Images
Chih-Ying Gwo | Chien Hsin University of Science and Technology

ICEAI-972
Parallel Algorithms for Computing Zernike Moments
An-Wen Deng | Chien Hsin University of Science and Technology
Chih-Ying Gwo | Chien Hsin University of Science and Technology

ICEAI-1117
Kernel PCA for i-Vector Speaker Verification System
Yi-Hsiang Chao | Chien Hsin University of Science and Technology

ICEAI-1148
Prediction of the Pandemic Influenza a Outbreaks based on Global Open Data
Ho-Chin Lin | Taipei Medical University
Chia-Yu Su | Taipei Medical University

ICEAI-1165
Service Experience Engineering Applied in Course Modules for Smart Living Topics
Chiu Chiao Chung | Nan Kai University of Technology
Cheng-Min Lin | Nan Kai University of Technology

ICEAI-1048
Design of a Dual-Mode High-Efficiency Buck Converter for Portable Applications
Mei Ling Yeh | National Taiwan Ocean University
Zi Chian Hong | National Taiwan Ocean University
Yu Chieh Cheng | National Taiwan Ocean University
ICEAI-1052
Modeling and Implementation of Adaptive Switched-Capacitor Step-Down DC-DC Converter for Piezoelectric Energy Harvesting
Yuen-Haw Chang | Chaoyang University of Technology
Chun-Hung Wang | Chaoyang University of Technology

ICEAI-1065
A Robust Mel-Bands Audio Fingerprint Based on Spectral Local Maximum Energy for Content Based Copy Detection
Fang Yuan | City University of Hong Kong
X. Xu | Tencent Video Group
L.M. Po | City University of Hong Kong
L. Feng | City University of Hong Kong
Y. Li | City University of Hong Kong

ICEAI-1076
Directional Acoustic Vibration Sensor Based on an Anisotropic Flat-Clad Tapered Fiber
Wei-Ren Wu | National United University
Chih-Yu Chen | National United University
Cheng-Ling Lee | National United University

ICEAI-1108
A Low Cost Fiber Optic Sagnac Interferometric Perimeter Intrusion Detection System
Ping-Tzan Huang | National Tsing Hua University
Guan-Zan Chen | National Tsing Hua University
Tai-Lang Jong | National Tsing Hua University
Chi-Wen Hsieh | National Chiayi University
Likarn Wang | National Tsing Hua University

ICEAI-1033
Comparisons of Individual and Group Replacement Policies for Two Machines Series Connection System
Wen Liang Chang | Cardinal Tien Junior College of Healthcare & Management
Mei Wei Wang | National Taiwan University of Science and Technology
ICEAI-1044
Development of Free-Leg Hexapod Machining Tool
Sunghee Choi | Electric Propulsion Research Division of Korea Electrotechnology Research Institute
Chang Nho Cho | Electric Propulsion Research Division of Korea Electrotechnology Research Institute
Hong-ju Kim | Electric Propulsion Research Division of Korea Electrotechnology Research Institute

ICEAI-1099
Study on the AM60Bs Mechanical Properties for the MgO-CNT Addition
Min Seok Moon | Korea Institute of Carbon Convergence Technology
Myeong Han Yoo | Korea Institute of Carbon Convergence Technology
Je Ha Oh | Korea Institute of Carbon Convergence Technology
Joon Hyuk Song | Korea Institute of Carbon Convergence Technology
Shin Jae Kang | Choubuk National University
Sung Mo Yang | Choubuk National University
Kee Do Woo | Choubuk National University

ICEAI-1102
Development of High-Pressure Diecasting Process for Vehicle Structure with Magnesium Alloy
Joon Hyuk Song | Korea Institute of Carbon Convergence Technology
Kyung-Jae Kim | Korea Institute of Carbon Convergence Technology
Myounghan Yoo | Korea Institute of Carbon Convergence Technology
Min Seok Moon | Korea Institute of Carbon Convergence Technology
Youngsoo Park | Korea Institute of Carbon Convergence Technology
Jeha Oh | Korea Institute of Carbon Convergence Technology
Sung Mo Yang | Choubuk National University
Shinjae Kang | Choubuk National University

ICEAI-1142
Study on a Micro Multilevel Aspheric Fresnel Lens Array Fabrication
Shun-Tong Chen | National Taiwan Normal University
Po-Tsung Lin | National Taiwan Normal University
ICEAI-1143
Development of a Novel Roll-to-Roll Imprinting System for Making Nanoscale Silver Wire Array
Shun-Tong Chen | National Taiwan Normal University
Chien-Ta Huang | National Taiwan Normal University

ICEAI-1174
Development of a High-Precision CNC Grinding Machine and Study of a Mono Crystalline Diamond Probe Grinding for Measurement of Surface Roughness
Shun-Tong Chen | National Taiwan Normal University
Sheng-Yu Shih | National Taiwan Normal University
Chien-Chih Chen | National Taiwan Normal University

ICEAI-1047
Wave Interaction with a Uniform Porous Cosine-Type Cylindrical Structure
Ching-Yun Yueh | National Taiwan Ocean University
Shih-Hsuan Chuang | Wayten Technology Co., Ltd
Chih-Ting Chang | National Taiwan Ocean University

ICEAI-1066
Eccentrically Loading on Strength Analysis of the Fillet Weld Groups
Wei T. Hsu | Chaoyang University of Technology
Zhe L. Zhang | Chaoyang University of Technology

ICEAI-1069
Analysis and Comparison of Compressive Strength of Box Column
Wei T. Hsu | Chaoyang University of Technology
Yu X Liu | Chaoyang University of Technology
Meng H Cheng | Chaoyang University of Technology
Rou Y Liu | Chaoyang University of Technology

ICEAI-1073
The Analysis of I-Shaped for Compression Members
Wei T Hsu | Chaoyang University of Technology
Rou Y Liu | Chaoyang University of Technology
ICEAI-1094
Effect of the Moisture Content on the Dynamic Behavior and Seismic Response of Concrete Pier
Baodong Liu | Beijing Jiaotong University
Rui Xu | Beijing Jiaotong University
Wenjuan Lv | Beijing Jiaotong University

ICEAI-1213
Pattern Data for Automatic Design of Free Form Panels
Sunkuk Kim | Kyung Hee University
Jeeyoung Lim | Kyung Hee University
Seunghyun Son | Kyung Hee University
Wonhyun Cho | Kyung Hee University

ICEAI-1098
Strength Analysis of a Small Size Crane’s Boom Using SP Test for Pick-Up Truck
Sung Mo Yang | Chonbuk National University
Hyo Sun Yu | Chonbuk National University
HeeYong Kang | Chonbuk National University
Jung Soo Kwon | Aenk
Seung June Choi | Chonbuk National University
In Deok Son | Chonbuk National University

ICEAI-1195
Seismic Performance Evaluation of FCC Reactor Vessel using Response Spectrum Analysis
Hee Yong Kang | Chonbuk National University
Jun Young Yim | Chonbuk National University
Sung-Mo Yang | Chonbuk National University
Dae Su Kim | Chonbuk National University
ICEAI-945
Locating Nipple in a Volume of Transverse Breast MR Images

Chih-Ying Gwo
Dept. of Information Management, Chien Hsin University of Science and Technology, Taiwan
ericgwo@uch.edu.tw

Abstract
The purpose of this paper is to propose a method to identify the breast nipple from a volume of transverse breast magnetic resonance images, this process being an unavoidable prerequisite for further image analysis such as in aiding lesion localization and fibroglandular tissue quantification. The proposed method first converts transverse images into coronal images (also sagittal images), and then the resulting images are rescaled according to the parameters of MRI system. Next, the statistic information of a background image is estimated to provide a threshold that is used to classify pixels of a breast nipple.

Key words: Transverse image, Coronal image, Sagittal image, Nipple, Breast MRI

1. Introduction
The nipple is one of several reliable and stable anatomical landmarks on the breast. Radiologists pay specific attention to the nipple as part of their examination of a breast image. It is also an effective reference for computer aided diagnosis (CAD) [1]. Nipple detection is a required procedure in varying purposes, such as identifying the tumor position of a breast, registration of left and right breasts, and nipple segmentation. Several methods have been proposed for nipple detection on mammograms in the past two decades. Most of these methods devote to extracting the breast border first and then track the feature variations along breast border to locate the nipple position. Méndez et al. [2] used the gradient of gray level to detect the breast border. Three features, maximum height of the breast border, maximum gradient, and maximum second derivative of the gray levels, were used to detect the nipple across the median-top section of the breast. Chandrasekhar and Attikiouzel [3] computed the average gradient of intensity in the direction normal to the breast border and directed inside the breast, it is found that there is a sudden and distinct change in this parameter close to the nipple. Mustra et al. [4] created a band area and cumulative intensities were calculated in the area. The nipple position inside or outside of the breast profile could be detected according to the cumulative intensity profile. Kinoshita et al. [5] applied the top-hat filter to enhance breast structure in the region of interest and found its largest response in the Radon domain. The nipple was detected as the convergence point of breast tissue components. Petroudi and Brady [6] proposed a local enhancement method to extract the fat-band including the skin-air interface of the breast.
The curvature variations were computed along the contours of the inner side and outer side of the fat-band. The location of the nipple was detected based on the curvature changes whether the nipple was in profile or not. Zhou et al. [7] developed a gradient-based boundary tracking algorithm to obtain the breast boundary. A two-stage nipple detection method was followed to identify the nipple location by using the geometric characteristics of nipple shapes and the texture features of glandular tissue. In order to enhance the precision of nipple location estimation, there are several approaches have been reported to detect the skin-air interface of the breast, such as fast marching algorithm [8], dynamically adaptive thresholding and connected-component analysis [9,10], active contour model algorithm [11], and iso-intensity contours [12].

The breast MR images are a volume of slices describing the breast structure from the top of the breast to the bottom [13]. There are some related literatures regarding to breast segmentation in the breast MR images. The whole-breast segmentation in sagittal breast MR images was studied by applying edge-enhancing filters and an edge linking algorithm to identify the chest wall line [14]. Another work in [15], authors proposed a method to extract the breast-air boundary by Otsu thresholding, and then an algorithm based on the gradient of image was designed to identify the pectoral muscle that was characterized by a geometric model to restrict the searching area. Before the breast segmentation, Wang et al. enhanced the image by a Hessian-based filter [16]. The only purpose of these studies is the breast segmentation. They all proposed detection methods for the identification of air-breast boundary and did not discuss how to determine the nipple of breast. In our previous work [17], a curve-fitting method is to simulate the top breast contour and the outside region of fitted curve is identified and segmented as the nipple. The purpose of this study is to develop a simple but robust method to roughly identify the nipple region in a volume of breast MR images. After the location of the nipple in every single slice is estimated, the nipple segmentation can be processed by the method proposed in [17].

2. Materials and Methods

Our proposed method involves three steps: (1) image acquisition; (2) image conversion; and (3) detection of the nipple.

2.1 Image Acquisition

In this study, ten breast MR images of women were acquired on a 1.5T dedicated spiral breast MRI system (Aurora System; Aurora Imaging Technology Inc., North Andover, MA, USA) using the Spiral RODEO pulse sequence. The imaging parameters were TR/TE = 29/4.8ms, flip angle = 45°, FOV = 360cm, slice thickness = 1.125mm, and matrix = 512×512. Some of images are shown in Figure 1.
2.2 Image Conversion
The schematic diagram of image conversion process is depicted in Figure 2. The MR images are transverse view and the total number of images is 160. The distance between two slices is 1.125mm and in-plane spatial resolution is $0.703 \times 0.703$mm/pixel. These whole images are presented on the left-hand side in Figure 2. Any coronal view image is acquired by arranging each particular row from a single transverse image to form an image with $512 \times 160$ pixels. Hence, the total number of coronal images is 512. Bilinear interpolation is applied to resize the resulting images into $512 \times 200$ pixels in order to have same spatial resolution in image $Y$ coordinate ($200 = 160 \times 2 \times 360 / (512 \times 1.125)$). The sagittal view images are obtained similarly.

The following three equations are coordinate transformations between three different image views.
where \((i, x_i, y_i), (i, x_i, y_i)\) and \((i, x_i, y_i)\) represent the voxel position for transverse, sagittal and coronal view in 3D-coordinate respectively. The first tuple in 3D-coordinate is the \(i\)th slice image. An example image conversion at (125,187) resulting sagittal and coronal images are shown in Figure 3.

\[\begin{align*}
\begin{bmatrix}
i_t \\ x_i \\ y_i
\end{bmatrix} &= \begin{bmatrix}
0 & 1 & 0 \\
199 & 0 & 0 \\
159 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
i_t \\ x_i \\ y_i
\end{bmatrix} = \begin{bmatrix}
0 & 159 & 0 \\
1 & 0 & 0 \\
0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
i_t \\ x_i \\ y_i
\end{bmatrix} \\
\begin{bmatrix}
i_s \\ x_s \\ y_s
\end{bmatrix} &= \begin{bmatrix}
0 & 0 & 1 \\
0 & 1 & 0 \\
-199 & 0 & 0
\end{bmatrix}
\begin{bmatrix}
i_s \\ x_s \\ y_s
\end{bmatrix} + \begin{bmatrix}
0 \\
0 \\
159
\end{bmatrix} \\
\begin{bmatrix}
i_c \\ x_c \\ y_c
\end{bmatrix} &= \begin{bmatrix}
0 & 0 & 1 \\
1 & 0 & 0 \\
0 & -1 & 0
\end{bmatrix}
\begin{bmatrix}
i_c \\ x_c \\ y_c
\end{bmatrix} + \begin{bmatrix}
0 \\
199 \\
0
\end{bmatrix}
\end{align*}\]
Consecutive nipple detection is shown in Figure 10. The detected nipple regions of left and right breast in purple color are the width or height of its bounding box being greater than $T_s$. This is an indicator to cease further nipple region detection for its own breast side.

Once the pixels of nipples are detected in coronal images, the coordinates of pixels are converted to transverse coordinates by Equation (2). As in Figure 5, the coordinates of pixels are converted and shown in $97^{\text{th}}$ transverse image. Two circles are drawn for each nipple in the figure. Their radii are $1.5 \times r_i'$ and $5 \times r_i'$. The $r_i'$ is defined in Equation (4).
\[ i' = \max \{ r | p = \| p - P_{i,j} \|, \forall p \in C_j \}, \text{ for } j \in \{l, r\}. \] (4)

where \( j \in \{l, r\} \) stands for the left or right nipple, \( C_j \) is the set of the pixels of left or right nipple in the \( i^{th} \) image and \( P_{i,j} \) is the centroid of the set given by Equation (5)

\[ P_{i,j} = \frac{\sum_{p \in C_j} P}{|C_j|}. \] (5)

**Figure 5:** The red pixels of nipple in coronal images are converted and displayed in the 97\(^{th}\) transverse image.

The segmentation of breast nipple is accomplished by the detection of the skin-air interface of breast. In order to have an efficient detecting area, the region of interest in the \( i^{th} \) slice image is defined in Equation (6) and with reference to Figure 5,

\[ R_j = \{ p | 1.5 \times r_j \leq \| p - P_{i,j} \| \leq 3 \times r_j \}, \text{ where } j \in \{l, r\}. \] (6)

Local illumination equalization is applied on the region \( R_j \) and the result is shown in Figure 6 (a). The edge points at the breast border are identified by the combination of thresholding and tracking process. The classified edge pixels are displayed in red color in Figure 6 (b) and (c).
The detected edge points fit the polynomial in Equation (7)

\[ a_0 x^2 + a_1 x y + a_2 y^2 + a_3 x + a_4 y + a_5 = 0, \]  

where \(a_i\) \((i=0,\ldots,5)\) are coefficients computed by the linear least squares method. Two simulated curves in cyan are superimposed on the both breast borders in Figure 6 (b). The region above the simulated curve is seen as the actual nipple region. This nipple region is more accurate than the detection from coronal images.

3. Conclusions

This study proposes an effective and robust solution to locate the nipple in a volume of breast MR images not only for a single image. A volume of transverse breast images are converted into a series of coronal images that are used to locate the nipple positions efficiently. The roughly detected nipple area is then used to confine the region of the top half of the breast. The breast boundary in the region is detected and fitted by a polynomial. Finally, the region above the fitted curve is readily identified as the nipple. The experimental simulations show that the proposed method achieves satisfactory results.

Acknowledgements

This work was supported by Ministry of Science and Technology, Taiwan, under research project number MOST 104-2221-E-231-013.

4. References


L. Wang, K. Filippatos, O. Friman, and H. K. Hahn, “Fully automated segmentation of the

Parallel Algorithms for Computing Zernike Moments

An-Wen Deng
Dept. of Information Management
Chien Hsin University of Science and Technology, Taiwan
awdeng@uch.edu.tw

Chih-Ying Gwo*
Dept. of Information Management
Chien Hsin University of Science and Technology, Taiwan
ericgwo@uch.edu.tw

Abstract
In this paper we discuss the thread-level parallel algorithms computing high order Zernike moments. Our proposed parallel algorithms are based on the combination of the q-recursive method and the Prata’s method with the symmetry by certain dihedral group. The experiments results show that our proposed method is fast and accurate. For computing all Zernike moments up to order 500, it needs only 3.499 sec. on a quad-core personal computer for a test image of pixels 512×512. By our proposed method, the error rate for the image reconstruction from Zernike moments up to order 500 is 0.001406, whereas the error rate for the image reconstruction by q-recursion method is 0.001777.

Keyword: Zernike Moments, Parallel computing, image processing

1. Introduction of Zernike Moments
For a set of Zernike polynomials $V_{nm}(x,y)$ which are orthogonal over the interior of a unit disc $D$, the Zernike moments $Z_{nm}$ are calculated by the following equation

$$Z_{nm} = \frac{n+1}{\pi} \iint_{(x,y) \in D} f(x,y) V^*_{nm}(x,y) \, dx \, dy \quad (1)$$

where $V^*_{nm}(x,y)$ denotes the complex conjugation of $V_{nm}(x,y)$. For a complex number $z=x+iy$, the Zernike polynomial is given by

$$V_{nm}(z) = R_{nm}(r)e^{im\theta} = R_{nm}(r)(\cos(m\theta) + i \sin(m\theta)) \quad (2)$$

where $R_{nm}(r)$ is the Zernike radial polynomial, $r$ is the length of vector $z$, the order $n$ is a non-negative integer, the repetition $m$ is an integer satisfying $n-|m|=$an even number and
\[ |m| \leq n, \text{ and } \theta \text{ is the angle between the vector and the } x\text{-axis counterclockwise. The radial polynomial } R_{nm}(r) \text{ is expressed as} \]

\[ R_{nm}(r) = \sum_{k=-n}^{n} R_{nmk} r^k \text{ where } R_{nmk} = (-1)^{\frac{n-k}{2}} \frac{(n+k)!}{(n-k)!(k+m)!(k-m)!} \]  

As an image with the size of \( N \times N \) pixels is projected onto the unit circle \( D \) with the radius of \( N \sqrt{2} \), the data of the image pixels can be regarded as in a two-dimensional table \( P(s,t) \) for \( s,t = 0,1,\ldots,N-1 \). The Zernike moments in Equation \( \text{找不到参照來源。} \) is computed by the zeroth-order approximation as follows

\[ \hat{Z}_{nm} = \frac{2(n+1)}{\pi N^2} \sum_{s,t=0}^{N-1} P(s,t) R_{nm}(r)(\cos(m\theta) - i \sin(m\theta)) \]  

The reconstructed image function can be expressed as

\[ \hat{f}(x,y) = \sum_{n,M} \sum_{\tau} Z_{nm} V_{\tau M}(x,y) \]  

where \( M \) is an integer. The error rate for the reconstructed image is defined as the normalized mean square error (NMSE)

\[ \varepsilon = \frac{\int_{D} \int_{D} |f(x,y) - \hat{f}(x,y)|^2 \, dxdy}{\int_{D} \int_{D} |f(x,y)|^2 \, dxdy} \]  

For an image of large size, 512×512 pixels or 1024×1024 pixels, to obtain an acceptable reconstructed image needs at least the information of Zernike moments up to order 200. The amount of computing Zernike moments is enormous. The utilization of the symmetry with finite groups is helpful to speedup computation time. The groups of reflections and rotations are adopted in [1, 2], such as dihedral groups

\[ D_4 = \{ \tau_\theta, t_\theta | \theta = 0, \pi/2, \pi, 3\pi/2 \}, \quad V_4 = \{ id, t_{\pi/2}, t_\theta, t_{3\pi/2} \} \]  

where \( \tau_\theta \) is the rotation matrix with \( \theta \) counterclockwise and \( t_\theta \) is the reflection matrix over the line \( \theta/2 \). Theoretically speaking, the algorithm of using the symmetry operated by the group \( D_4 \) (or \( V_4 \) respectively) can be speeded up to 8 times (or 4 times respectively). Besides the use of symmetry properties, there are other ways to speed up algorithms for computing
Zernike moments. Parallelization is also a good alternative solution. In this paper, we will focus on the thread-level parallelism for the multi-core computers.

2. Proposed Algorithms

2.1 Q-Recursive Method and Modified Prata’s Method

Our proposed method is based on the combination of q-recursive method and the Prata’s method. Let us recall these two methods in the section. The q-recursive method was introduced by Chong et al. [3], which is based the following recurrence:

\[
R_{m,n}(r) = K_1R_{n,n+4}(r) + K_2 \frac{K_2}{r^2} R_{n,n+2}, \quad m = n - 4, n - 6, \ldots, 1 \quad \text{or} \quad 0 \quad (8)
\]

with the initial conditions.

\[
R_{0,0}(r) = r^n, n \geq 0 \quad \text{and} \quad R_{n,n-2}(r) = nr^n - (n-1)r^{n-2}, n \geq 2 \quad (9)
\]

Moreover, the coefficients satisfy

\[
K_1 = \frac{(m+4)(m+3)}{2} - (m+4)K_2 + \frac{K_2(m+m+6)(n-m-4)}{8}
\]

\[
K_2 = \frac{K_2(n+m+4)(n-m-2)}{4(m+3)} + (m+2) \quad (10)
\]

The other method, namely the Prata’s method, originally introduced in [4], uses the recurrence given by

\[
R_{m,n}(r) = rC_1R_{n-1,m+1}(r) + C_2R_{n-2,m}(r) \quad (11)
\]

where the constants can computed as follows:

\[
C_1 = \frac{2n}{m+n}, \quad C_2 = \frac{m-n}{m+n} = 1 - C_1, \quad \text{for} \quad m = n, n - 2, \ldots, 1 \quad \text{or} \quad 0 \quad \text{.} \quad (12)
\]

A modified version of Prata’s method computes the radical polynomials \(R_{m0}\) by using the recurrence:
which needs a time complexity of \( O(N^2 M^2) \).

It is noted that using either one of both methods to compute Zernike moments for high order can induce sightible errors in the reconstructed image. In our experiments, the reconstruction from the Zernike moments computed by using the modified Prata's method is inacceptable when the maximal order is greater than 95. The inaccurate values of the Zernike radial polynomial \( R_{nm}(r)=0 \) are calculated by q-recursive method for \( n \geq n_r, |m| \leq 106 \). For the calculation at high Zernike moment order, the method will destroy the algorithm. This phenomenon is observed in [5].

2.2 Proposed Method in Serial Version

For the maximal Zernike moment \( M \geq 250 \), the reconstructed image from the computed Zernike moments using q-recursive method has sightible errors. Although the computed Zernike radial polynomial \( R_{nm}(r) \) by using the modified Prata's method are not correct for \( n > 95 \) and large \( m \), the computed values for \( R_{nm}(r) \) are usable for small repetition \( m \) and has better estimate for small \( r \) than the one by using q-recursive method. Our main idea is to combine these two methods to obtain algorithms with better performance.

Algorithm A:

Let \( Z[n][m] \) denote the element of the array which stores the values of Zernike moments \( Z_{nm} \); \( R_{nm} \) denotes the memory of storing the temporary computed value for the Zernike radial polynomial \( R_{nm}(r) \).

1. Compute all constants \( C_1, C_2 \) as in Equation (12) for Prata's method, and compute all constants \( K_1, K_2, K_3 \) as in Equation (10) for q-recursive method for all \( n, m \) where \( n \leq M \).
2. For each \((s, t)\) in \( A(Z) \)
   \[ x = 2sN + 1 \]
   \[ y = 2tN + 1 \]
   \[ r = \sqrt{x^2 + y^2} \]
2a. Using linear recurrence in [1] to compute \( \cos \theta_s, \sin \theta_s, r^k \) for \( m, k = 0, 1, \ldots, M \)
2b. Compute
   \[ Z[0][0] = Z[0][0] + 2/\pi N^2 f(x, y) \]
2c. For \( n = 1 \) to 3 step 1
Algorithm A takes a time complexity of $O(N^2M^2)$. The need of total memory has a complexity of $O(N^2 + M^2)$, where the image $f(x,y)$ and the array $Z[][]$ require $O(N^2)$ and $O(M^2)$ respectively. Other arrays and variables for storing the temporary values of $\cos m\theta$, $\sin m\theta$, $r^k$ and $R_{nm}(r)$ contribute a complexity of $O(M)$.

Algorithm A can be speeded up by using $D_4$ symmetry. This modification can speed the algorithm up to 8 times.

### 2.3 Thread-Level Parallelism

The control variables $s$, $t$ in the outer loop of computing Zernike moments have dependencies on two indices $n$ and $m$ for storing the values of Zernike moments $Z_{nm}$. A careless parallelizing for-loop will definitely cause the race conditions: either two threads write to the same memory location simultaneously or one thread reads and another thread writes to the same memory location.

To avoid the race conditions, the synchronization method is a common solution [6]. However, a heavy synchronization slows down the performance. Some parallel program with heavy
synchronization is even slower than the serial version. The parallel algorithm, denoted Algorithm B, is a slight modification for Algorithm A in which the foremost outer for-loop is replace by the parallel-for loop; moreover, the light-weight synchronization is used within the parallel-for loop only when the update of $Z[n][m]$ is necessary.

Since the extra memory need for a thread takes a complexity of $O(M)$, for $P$ multithreads, an image with the size of $N\times N$ pixels and maximal Zernike moment order $M$, the total memory for Algorithm B has a complexity of $O(PM+N^2)$. For a high order $M$ and a large $P$, the parallelism saves a lot of computation time and brings a mild increase of extra memory need. Since the synchronization also costs some time, the performance of parallelized algorithms slows down quite a lot when the order $M$ is low. The parallelizing approach is applied to Algorithm A with $D_4$ speedup, which we denote it by Algorithm B+.

3. Experimental Results

We implement our algorithms in C/C++ code with parallel library openMP [7] which supports the thread-level parallelism and has a plenty of thread synchronization mechanisms; and the source code is complied with the TMD-GCC 4.9.2 64-bit C/C++ release compiler with optimization O2 and disabling automatic parallelization. All of computations use the 64-bit double precision float format. The computer is installed with OS win7 and the processor is Intel i7-4790 quad-core 3.6 GHz which supports eight multithreads; and the RAM is 8 GB.

The image 'Lena' of 512×512 pixels is shown in Figure 1(a). We simulate three different methods: the proposed method, q-recursive method and the modified Prata's method. The error rate of the reconstructed images at different maximal order between 0 and 500 are shown in Figure 2 It is interesting to observe that three different recursive methods have the same reconstruction error rate when the order is less than 50.
The reconstructed image of the modified Prata's method becomes inaccurate when the medium maximal Zernike order $M$ is greater than 95. Both of the proposed recursive method in Algorithm A and the q-recursive method have the similar reconstruction error for the medium maximal Zernike order between 95 and 250. For high maximal order $250<M$, the proposed method, i.e. Algorithm A, has a better performance, whereas the reconstructed image of the q-recursive method has sightible concentric circles around the center of the image. At maximal order 500, the reconstruction error rate of Algorithm A is 0.001406, whereas the error rate of q-recursion method is 0.001777.

![Error Rate of Reconstructed Images Using Different Recursive Methods](image)

**Figure 2.** The error rate of the reconstructed images using different recursive methods

We evaluate the speed performance of the parallel algorithm given by Algorithm B+ up to maximal Zernike moment $M \leq 500$. Let $t_0$ denote the elapsed time for Algorithm A. Let $t_1$ denote the elapsed time for Algorithm A with $D_4$ speedup. Let $t_i$ denote the elapsed time for Algorithm B+ using $i$ multithreads.

Let the total speedup factor be $s_0=t_0/t_1$ and the parallel speedup factor be $p_i=t_i/t_1$. Some experiment results are shown in Table 1 and in Figure 3. For the low maximal order $M \leq 100$, some parallel factor $p_i$ is small since parallelism causes a heavy synchronization; in fact, the use of Algorithm A with speedup by $D_4$ is already very fast, parallelism is not recommended to use in this situation. Observing the total speedup factor $s_0$ is between 7.567 and 7.630 for maximal Zernike moment order $M \geq 200$, which is close to our theoretical prediction for $D_4$ which is 8 times speedup.
For maximal order $M \geq 200$, the parallel speedup factor $p_8$ lies between 3.318 and 3.641; and this is an acceptable parallelism performance for a quad-core computer. This concludes the parallelism using synchronization method is suitable for high maximal Zernike moment order.

For a geometrical view of parallel speedup in our implementation of Algorithm B+ is shown in Figure 3(b), which can be represented as a surface where $s_P = f(M, P)$, $M$ is the maximal order and $P$ is the number of threads in use.

<table>
<thead>
<tr>
<th>Maximal Order</th>
<th>$s_1$</th>
<th>$s_2$</th>
<th>$s_3$</th>
<th>$s_4$</th>
<th>$s_5$</th>
<th>$s_6$</th>
<th>$s_7$</th>
<th>$s_8$</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>14.365</td>
<td>1.931</td>
<td>7.567</td>
<td>1.019</td>
<td>1.855</td>
<td>14.117</td>
<td>0.713</td>
<td>2.708</td>
</tr>
</tbody>
</table>

Figure 3. (a) the elapsed time in sec. for Algorithm A with speedup by $D_4$ and Algorithm B+ with number of threads $p = 2, 4, 8$ (b) The surface given by the parallel factor function $s_P = f(M, P)$ using Algorithm B+

4. Conclusion

The proposed method yields accurate numerical results, especially for high-order moments. The experimental results show that the proposed parallel method takes 3.499 seconds to compute the top 500-order Zernike moments of an image with 512×512 pixels. In the use of eight multithreads computing high-order Zernike moments, the parallel speedup factor lies between 3.318 and 3.641, which is a good parallelism performance for a quad-core computer. The NMSE is 0.001406 by using Algorithm A, whereas the error rate of the image reconstruction by q-recursion method is 0.001777. When computing high-order Zernike
moments, the proposed method outperforms other compared methods in terms of speed and accuracy.

Acknowledgements
This work was partially supported by Ministry of Science and Technology, Taiwan, under research project number MOST 104-2221-E-231-013.

5. References
Timothy G. Mattson, Beverly A. Sanders and Berna L. Massingill, Patterns for Parallel Programming (2004)
Barbara Chapman, Gabriele Jost and Ruud van der Pas Using OpenMP: Portable Shared Memory Parallel Programming (2008)
ICEAI-1117
Kernel PCA for i-Vector Speaker Verification System

Yi-Hsiang Chao
Department of Applied Geomatics, Chien Hsin University of Science and Technology,
Taiwan
E-mail address: yschao@uch.edu.tw

Abstract
In recent years, the i-vector approach has become the current state-of-the-art method for
speaker verification. The i-vector approach is a factor analysis technique that can perform
speaker verification via a cosine similarity measurement between the target speaker i-vector
and a test i-vector in a low-dimension total-variability space which models both speaker and
channel variability. However, the conventional i-vector systems used the linear transformation
techniques, such as Principal Component Analysis (PCA), to process the factor analysis. In this
paper, we design a new kernel-based framework which replaces the linear transformation
technique by a kernel-based nonlinear transformation technique, named Kernel Principal
Component Analysis (KPCA) for the i-vector speaker verification system. Our experimental
results show that the proposed method outperforms the conventional i-vector speaker
verification approach.

Keywords: Speaker Verification, i-vector, Principal Component Analysis (PCA), Kernel
Principal Component Analysis (Kernel PCA)

1. Introduction
Speaker verification is a hypothesis testing problem which aims to determine if a speaker is
who he or she claims to be. In recent years, the i-vector method [2] has become the current
state-of-the-art approach for speaker verification. The i-vector method is a factor analysis
technique motivated by Joint Factor Analysis (JFA) [1]. In contrast to JFA that models
separately between-speaker and within-speaker variability in a high-dimension space of
GMM-supervectors [4], the i-vector method forms a low-dimension subspace of the
GMM-supervisor space, named the total-variability space, which represents both speaker and
channel variability. Each GMM-supervisor is formed by concatenating all mean vectors of a
Gaussian Mixture Model [5] adapted from the Universal Background Model (UBM) [6] using
the Maximum a Posteriori (MAP) [7] estimation technique. The projection of a
GMM-supervisor onto the low-dimensional total-variability space is called i-vector.

The conventional i-vector method performs speaker verification via a cosine similarity
measurement between the target speaker i-vector and a test i-vector in a low-dimension
total-variability space which is constructed by performing Principal Component Analysis (PCA) [9] on all training GMM-supervectors. However, PCA is a linear transformation technique that has been shown to be worse than Kernel Principal Component Analysis (Kernel PCA) [10] for representing the distribution of most real-world data. The objective of this paper is to design a new kernel-based framework which attempts to replace the linear transformation technique PCA by a kernel-based nonlinear transformation technique Kernel PCA for improving the conventional i-vector speaker verification systems.

The remainder of the paper is organized as follows. Section 2 introduces the conventional i-vector speaker verification system. Section 3 describes the proposed i-vector system using Kernel PCA. Section 4 contains the experimental results. Finally, in Section 5, we present our conclusions.

2. The I-Vector Speaker Verification System

The i-vector method [2] is a factor analysis technique that can perform speaker verification via a cosine similarity measurement between the target speaker i-vector $v_{\text{target}}$ and a test i-vector $v_{\text{test}}$ in a low-dimension total-variability space which models both speaker and channel variability. The cosine similarity measurement can be represented by

$$
\text{Score}(v_{\text{target}}, v_{\text{test}}) = \frac{v_{\text{target}} \cdot v_{\text{test}}}{\|v_{\text{target}}\| \|v_{\text{test}}\| \begin{cases} \geq \theta & \text{accept} \\ < \theta & \text{reject} \end{cases}}
$$

(1)

where $\theta$ is the decision threshold that can determine whether a test i-vector $v_{\text{test}}$ is from the target speaker or not. Any input speech utterance $U$ can be represented by an i-vector $v$ that is obtained from

$$
x = x_{\text{UBM}} + Ev,
$$

(2)

where $x$ is a GMM-supervector [4] trained using an utterance $U$, $x_{\text{UBM}}$ is a speaker- and channel-independent UBM-supervector, and $E$ is a low rank total variability matrix [2] representing the primary directions of variability across all speakers’ speech data.

2.1 GMM-UBM

In Eq. (2), $x$ and $x_{\text{UBM}}$ are formed by concatenating the mean vectors of a Gaussian Mixture Model [5] $\lambda$ and a Universal Background Model (UBM) [6], respectively. One successful adaptation approach, namely the GMM-UBM [6], has been widely used to obtain the GMM and UBM in speaker recognition applications. This approach first pools all speech data from a large number of background speakers to train a single speaker- and channel-independent GMM with a large number of mixture components, namely the UBM, via the
Expectation-Maximization (EM) algorithm [7]. This approach then adapts the well-trained UBM to the GMM $\lambda$ using a given utterance $U$ via the Maximum a Posteriori (MAP) [7] estimation technique.

2.2 Principal Component Analysis (PCA)
The process of training a low rank total variability matrix $E$ in Eq. (2) is similar to learning the eigenvoice matrix [8]. $E$ is constructed by performing Principal Component Analysis (PCA) [9] on all GMM-supervectors $\{x_1, x_2, \ldots, x_N\}$ produced from $N$ training utterances. In other words, the column vectors of $E$ are the eigenvectors of the covariance matrix $C$ corresponding to the largest $k$ eigenvalues, where $k < N$, and

$$C = \frac{1}{N} \sum_{n=1}^{N} (x_n - \bar{x})(x_n - \bar{x})^T,$$  \hspace{1cm} (3)

where $\bar{x}$ is the mean of $\{x_1, x_2, \ldots, x_N\}$.

2.3. Within Class Covariance Normalization (WCCN)
We can integrate the Within Class Covariance Normalization (WCCN) [3] into Eq. (1) to remove the nuisance effects in the total variability space. The WCCN is a channel compensation technique that has been successfully applied in the speaker factor space [3]. It consists in computing the within class covariance matrix $\Sigma$ in the total factor space using a set of background impostors:

$$\Sigma = \frac{1}{S} \sum_{s=1}^{S} \frac{1}{n_s} \sum_{i=1}^{n_s} (v_i - \bar{v})(v_i - \bar{v})^T,$$  \hspace{1cm} (4)

where $S$ is the total number of background impostors, and $\bar{v}_s$ is the mean of $n_s$ i-vectors $\{v_1^s, \ldots, v_{n_s}^s\}$ from the $s$-th background impostor, $s = 1, 2, \ldots, S$. Suppose $v_1$ and $v_2$ are two input i-vectors, the WCCN-based cosine similarity measurement [3] can be represented by

$$Score_{WCCN}(v_1, v_2) = \frac{v_1^T \Sigma^{-1} v_2}{\sqrt{v_1^T \Sigma^{-1} v_1} \sqrt{v_2^T \Sigma^{-1} v_2}}.$$  \hspace{1cm} (5)

3. Kernel PCA for i-vector Method
In this paper, we propose using a kernel-based transformation technique, named Kernel Principal Component Analysis (Kernel PCA) [10], to process the factor analysis in the i-vector speaker verification system. Kernel PCA is an extension of PCA using techniques of kernel methods [11]. Let $\Phi$ be a nonlinear function that maps $\{x_1, x_2, \ldots, x_N\}$ into the implicit higher
dimensional (maybe infinite) feature space \( F \), and \( \bar{x}^\Phi \) be the mean of \( \{ \Phi(x_1), \Phi(x_2), \ldots, \Phi(x_N) \} \). To do PCA in \( F \) for the covariance matrix

\[
C^\Phi = \frac{1}{N} \sum_{n=1}^{N} (\Phi(x_n) - \bar{x}^\Phi)(\Phi(x_n) - \bar{x}^\Phi)^T,
\]

we have to find eigenvalues \( \lambda \) and eigenvectors \( e \) in \( F \) satisfying

\[
\lambda e = C^\Phi e. \tag{7}
\]

Usually, it is impossible to directly compute \( \Phi(x) \). To overcome this difficulty, a promising approach is to characterize the relationship between the data samples in \( F \), instead of computing \( \Phi(x) \) directly. This is achieved by introducing a kernel function [11]

\[
k(x,y) = \langle \Phi(x), \Phi(y) \rangle,
\]

which is the inner product of two vectors \( \Phi(x) \) and \( \Phi(y) \) in \( F \). The function \( k(\ ) \) must be symmetric positive and obey the Mercer’s condition [11]. A number of kernel functions exist, the most popular kernel is the Radial Basis Function (RBF) kernel [11] function:

\[
k(x,y) = \exp(-\frac{\|x-y\|^2}{2\sigma^2}). \tag{9}
\]

where \( \sigma \) is a tunable parameter. From the theory of reproducing kernels, the solution of \( e \) must lie in the span of all training samples mapped in \( F \), i.e.,

\[
e = \sum_{n=1}^{N} \alpha_n (\Phi(x_n) - \bar{x}^\Phi). \tag{10}
\]

Let \( \mathbf{a}^T = [\alpha_1, \ldots, \alpha_N]_{n \leq N} \), and substitute Eq. (10) into Eq. (7). According to [10], finding \( e \) is equivalent to solving \( \mathbf{a} \) in the eigenvalue problem:

\[
N \lambda \mathbf{a} = \mathbf{K} \mathbf{a}. \tag{11}
\]

where \( \mathbf{K} \) is an \( N \times N \) matrix with element \((\mathbf{K})_{ij} = \langle \Phi(x_i), \Phi(x_j) \rangle \), \( 1 \leq i, j \leq N \), where \( \Phi(x_n) = \Phi(x_n) - \bar{x}^\Phi \), \( n = 1, 2, \ldots, N \). Therefore, the projection of a GMM-supervector \( x \) can be expressed as the projection of \( \Phi(x) \) onto \( e \), i.e.,
\[ v = e^T (\Phi(x) - \Phi(x_{UBM})) \]
\[ = \sum_{n=1}^{N} a_n \Phi(\bar{x}_n)^T (\Phi(x) - \Phi(x_{UBM})) \]
\[ = \sum_{n=1}^{N} a_n (\langle \Phi(\bar{x}_n), \Phi(x) \rangle - \langle \Phi(\bar{x}_n), \Phi(x_{UBM}) \rangle). \]  

In this way, \( v \) is one of elements in the \( k \)-dimensional new i-vector using Kernel PCA, where \( k < N \).

### 4. Experiments

#### 4.1 Experimental Setup

Our speaker verification experiments were conducted on the speech data extracted from the XM2VTSDB multi-modal database [12]. In accordance with “Configuration II” described in Table 1 [12], the database was divided into three subsets: “Training”, “Evaluation”, and “Test”. In our experiments, we used “Training” to build an UBM, each target speaker’s GMM, a total-variability space and a within-class covariance matrix, and “Evaluation” to estimate the decision threshold \( \theta \) in Eq. (1). The performance of speaker verification was then evaluated on the “Test” subset.

<table>
<thead>
<tr>
<th>Session</th>
<th>Shot</th>
<th>199 clients</th>
<th>25 impostors</th>
<th>69 impostors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>Training</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td></td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td></td>
<td>Evaluation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td></td>
<td></td>
<td>Test</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

As shown in Table 1, a total of 293 speakers \(^1\) in the database were divided into 199 clients (target speakers), 25 “evaluation impostors”, and 69 “test impostors”. Each speaker participated in 4 recording sessions at approximately one-month intervals, and each recording session consisted of 2 shots. In a shot, every speaker was prompted to utter 3 sentences “0 1 2 3 4 5 6 7 8 9”, “5 0 6 9 2 8 1 3 7 4”, and “Joe took father’s green shoe bench out”. Each utterance, sampled at 32 kHz, was converted into a stream of 24-order feature vectors, each consisting of 12 Mel-Frequency Cepstral Coefficients (MFCCs) [13] and their first time derivatives, by a 32-ms Hamming-windowed frame with 10-ms shifts.

---

\(^1\) We discarded 2 speakers (ID numbers 313 and 342) because of partial data corruption.
We used all 199 clients’ utterances from sessions 1 and 2 to train an UBM, represented by a GMM with 256 mixture components, and then adapted the mean vectors of the UBM to each client’s GMM according to his/her 12 (2×2×3) utterances from sessions 1 and 2. Moreover, we built a 200-dimension total-variability space using the GMM-supervectors from 2388 utterances of 199 clients (12 utterances per speaker and one adapted GMM per utterance). We also produced 2388 i-vectors from 2388 GMM-supervectors via PCA or Kernel PCA to calculate the within-class covariance matrix.

Next, we used 6 utterances per client from session 3, along with 24 (4×2×3) utterances per evaluation-impostor over the four sessions, to estimate the decision threshold \( \theta \). In the performance evaluation, we tested 6 utterances per client in session 4 and 24 utterances per test-impostor over the four sessions, which produced 1,194 (6×199) client trials and 329,544 (24×69×199) impostor trials.

4.2 Experimental Results

We implemented the conventional i-vector system using a cosine similarity measurement defined in Eq. (5) (“Ivector”). For the purpose of performance comparison, we implemented the proposed i-vector system using Kernel PCA with the Radial Basis Function (RBF) kernel (“KPCA_Ivector”). Fig. 1 shows the results of speaker verification evaluated on the “Test” subset in terms of DET curves [14]. From Fig. 1, it can be seen that the curve “KPCA_Ivector” is obviously better than that of the state-of-the-art system, “Ivector”.
Furthermore, we measured the Detection Cost Function (DCF) [15], which reflects the performance at a single operating point on the DET curve. The DCF is defined as

\[ C_{DET} = C_{Miss} \times P_{Miss} \times P_{Target} + C_{Fa} \times P_{Fa} \times (1 - P_{Target}), \]

where \( P_{Miss} \) and \( P_{Fa} \) are the miss probability and the false-alarm probability, respectively; \( C_{Miss} \) and \( C_{Fa} \) are the respective relative costs of the detection errors; and \( P_{Target} \) is the \textit{a priori} probability of the target speaker. In our experiments, \( C_{Miss} \) and \( C_{Fa} \) were both set to 1, and \( P_{Target} = 0.5 \). This special case of DCF is known as the Half Total Error Rate (HTER) [16]. Table 2 summarizes the experimental results based on the HTER. From Table 2, it is clear to show that an 11% relative improvement was achieved by “KPCA_Ivector” (the HTER = 2.75%), compared to 3.09% of the state-of-the-art system, “Ivector”. Thus, the proposed kernel-based i-vector system outperforms the conventional i-vector system.

![Fig. 1: DET curves for “Test”](image)

Table 2: HTERs for “Test”

<table>
<thead>
<tr>
<th>Methods</th>
<th>DCFs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ivector</td>
<td>0.0309</td>
</tr>
<tr>
<td>KPCA_Ivector</td>
<td>0.0275</td>
</tr>
</tbody>
</table>

5. Conclusion
The i-vector speaker verification approach is a factor analysis technique that can perform speaker verification via a cosine similarity measurement between the target speaker i-vector and a test i-vector in a low-dimension total-variability space which models both speaker and channel variability. However, the conventional i-vector systems used a linear transformation technique, named Principal Component Analysis (PCA), to process the factor analysis. In this paper, we have presented a new kernel-based framework which replaces the linear transformation technique by a kernel-based nonlinear transformation technique, named Kernel Principal Component Analysis (Kernel PCA). Our experimental results have shown that the proposed kernel-based i-vector method outperforms the conventional i-vector speaker verification system

6. Acknowledgment
This work was funded by the Ministry of Science and Technology (MOST), Taiwan, under Grant: MOST104-2221-E-231-009.

7. References


http://www.nist.gov/speech/tests/spk/index.htm

ICEAI-1148
Prediction of the Pandemic Influenza a Outbreaks based on Global Open Data

Ho-Chin Lin
Graduate Institute of Biomedical Informatics, Taipei Medical University, Taiwan
E-mail address: poiu2131@gmail.com

Emily Chia-Yu Su*
Graduate Institute of Biomedical Informatics, Taipei Medical University, Taiwan
E-mail address: emilysu@tmu.edu.tw

1. Background
Influenza A virus is usually transmitted among poultry with large variation and can be infected across different species. It has also been observed that the genomics of influenza A virus in human contains genes in avian influenza virus, which indicates that poultry can be considered as a main host of the Influenza A virus. The aim of this study is to predict global outbreaks of influenza A virus based on factors obtained from open data resources and visualize the analytical results.

2. Methods
The influenza A virus outbreak data and related factors will be extracted from global open resources, including influenza A records, global geographical, environmental, and climatic data. First, we parsing the collected and sorted out the data by SAS enterprise guide 6.1, then we delimit the value definition of the influenza A epidemic and use the SAS enterprise miner 13.2 to analyze. Third, we got the analysis results by the prediction. In order to find variable which is more important, we choose the several prediction model, as decision tree, neural network. We through the prediction results to discuss the factors impact. In addition, comprehensive consolidation, cross-analysis, post-analysis, and the relative probability of being infected in each region will be calculated. Our prediction results will be validated and compared with historic records. We also use the highly pathogenic avian influenza data (H5 and H7 type) from OIE to set a map, we can see the density of epidemic area. By this map to find out the trends of influenza A type in animals cases’ occur

3. Expected Results and Conclusion
In the prediction system, various types of global data will be incorporated and basic descriptive analysis will be conducted. In our preliminary results, data mining techniques are used to predict the outbreaks of influenza A virus based on climate data. In the expected results that we can see the human cases distribution of influenza A in the world. Also we choose the predicted
method of decision tree, regression and neural network. In these results show that decision tree has best prediction result, 0.699 of accuracy and 0.777 of area under the curve in the relationship between human case and temperature. In the future, more factors will be incorporated to increase the prediction results, and the importance of different factors will be evaluated by feature selection techniques. Also we will focus on the Asia, because there occurs more and more highly pathogenic cases in Asia. And hopefully, we can early find out where will be highly probability occur of influenza A to prevent and make precautions. Hopefully, through a variety of comprehensive data, our system can accurately predict bird flu outbreaks and prevent contagious pandemics in the future.

Keywords: avian influenza prediction, open data analysis, map visualization
ICEAI-1165
Service Experience EngineeringApplied in Course Modules for Smart Living Topics

Chiu-Chiao Chung *
Department of Digital Living Innovation, Nan Kai University of Technology, Taiwan (R.O.C.)
jen@nkut.edu.tw

Cheng-Min Lin
Department of Digital Living Innovation, Nan Kai University of Technology, Taiwan (R.O.C.)
lcm@nkut.edu.tw

Abstract
The Service Experience Engineering applied in sandwiched course modules is proposed for students by progressive approaches with interdisciplinary learning of the smart living topics. The sandwiched course module is designed for students with majors of Information and Communication Technologies from the elementary to the high-end courses. Students succeeded on the trial of sandwiched course modules, and they accumulated valuable experiences since teaching and learning promote and enhance each other.

Keywords: the Service Experience Engineering, Sandwiched course module, Smart Living Technology, Information and Communication Technology

1. Introduction
Any communication device or application, computer and network hardware and software, and the various services and applications associated with them as we know are the information and communications technology (ICT) included. The importance of ICTs lies more in its ability to create greater access to information and communication in underserved populations than in the technology itself. Most of countries around the world have established organizations for the promotion of ICTs, because it is such an important technology to exacerbate the economic development.

Note that it is not just information technologies, but service technologies developed across wide spectrums, that have been changing the entire structure of world competition. Services technologies have restructured economy, service companies with economic power and scale increase markedly relative to manufacturing companies; they would redefine their roles versus those of manufacturing (Quinn, 1992).

Traditionally, a sandwich course is a three-to-five year undergraduate degree with a work
placement integrated into the course. Sandwich courses are more common amongst business-related subjects, but can also be run in a variety of other subjects, such as engineering, computer science, mathematics and a handful of humanities disciplines. Some companies run sandwich courses in partnership with universities, where the placement year is spent working at that specific company. There are some advantages for students to build up their work experiences, enhance employability, and establish contacts in their chosen industries. Research conducted by ASET (ASET, 2000) showed that students on sandwich degrees were more likely to achieve a better grade in their degree than non-placement students; perhaps due to the increased confidence, motivation and professionalism engendered by the placement. Some sandwich courses are run by companies in partnership with a university. Students get to do placements at some specific company and increase chances of getting a job when they graduate if they are interested in working for the company. However, sandwich courses are dominated by business, engineering and science subjects. Consequently, most of students won’t get the same opportunity to boost their employability.

In order for students in college to gain their ICTs knowledge as well as learn service based on the interdisciplinary courses, a sandwiched course module is proposed for students by progressive approaches with interdisciplinary learning of ICTs with the smart living topics.

2. Course Modules Implementing

The proposed sandwiched course modules architecture shown in Fig. 1 (Chung and Lin, 2016) includes service-learning courses, interdisciplinary foundation course modules, mid-level core courses, project-based courses, and field practicum for industrial applications, for freshmen to seniors, respectively.

![Fig. 1: Architecture of the double-sandwiched course modules.](image)

Within the sandwiched course, the outer layers include field practicum for industrial applications and service-learning courses. The purpose is to expand he depth and breadth of
innovation course and learning process by combining with external resources. Followed by the inner core layer are consisting of interdisciplinary foundation course modules, mid-level core courses, and project-based courses. These courses are focused on arousing students’ interests in learning, and designed to strengthen students’ prior knowledge, as well to intensify their expertise. Furthermore, through project-based courses, students would utilize the expertise to achieve their learning outcomes.

The service-learning courses are designed by means of linking the local community development and care services for the vulnerable. Base on implementing studies, by way of the “Problem Based Learning” (PBL) and the “Action Learning” (AL), the teaching and learning objects and fields are also extended to students’ activities and community services. Students would experience "Humanistic-oriented" spirits by participating in public service activities, and expand their experiences and opportunities in the process of ‘Learning by doing’, through which, they gain abilities of knowledge integrating, problem solving and decision making.

The interdisciplinary foundation course modules are designed to explore issues and ideas that cross the boundaries of individual subject areas. Based on the topics of “Smart Living” or “Smart Living Technology”, the interdisciplinary foundation course modules, such as “Introduction to Arts and Humanities”, “Introduction to Living Industry”, “Introduction to Smart Living”, “Introduction to Innovation and entrepreneurship”, and “Modern Domestic Technology”, etc., provide students the foundation learning for Humanities and Sciences.

The mid-level core courses and project-based courses are interdisciplinary professional course modules, which are provided by Inter-institution teaching Unions for college seniors and graduates, to train students to become an expert in the cross field of innovations and applications.

For the expertise based on topics of technology, design, and living field, the mid-level courses are developed including “Technology Projects”, “Enterprise Case Studies”, “Interface Design of Human-Machine Interaction”, “Cognitive Psychology”, “Service Design Thinking”, and “Behavior Ethnography of Technology Aid Living”. Fig. 2 explains the topics of mid-level courses.
The course modules developed for students with majors of Information and Communication Technologies, in Nai-Kai University of Technology (NKUT), Taiwan, R.O.C. since academic year of 2012. Once they finished the interdisciplinary foundation course modules (2013) and mid-level core courses (2014), 5-6 of them took the project-based courses while they are senior (2015).

Lugu Township in Taiwan is one of the famous cradles of Dongding Oolong tea. However, most of tea factories declined gradually. This is also a successful story to reform a tea factory at Chuxiang Village of Lugu Township into a smart living field with basic architecture. There are three stages, at first students learned how to arrange and embellish the tea factory, then smart living technologies were introduced to those local culture workers, such as mobile applications (Apps). Finally, the Customer Service Process Design with the Service Experience Engineering (SEE) technology was introduced. For those senior students as taking the project-based courses, the SEE technology is the most important learning strategy for studying and practicing. Here, design thinking principles and process are summarized, and real examples of design thinking for Chuxiang Village in action will be described.

Design thinkers try to balance what is desirable from a user's point of view with what is feasible with technology and viable from a business factors perspective (Costa & Rodriguez, 2013, Phone, et. al., 2014). The general overview of design thinking begins with the five principles behind the approach and the process as shown in Fig. 3. Each of these principles translates into a process or action that brings it to life.
The SEE is also applied to observe consumer’s behavior and investigate demand groups during the course of action, and finally to construct an excellent process of customer service for the local people at Chuxiang Village.

The design challenge starts with a user focus. To help frame the challenge, three questions (Morris and Warman, 2015) are evaluated:
1. Who is the user and what benefit are they trying to provide?
2. Why do they want to do this?
3. What's problem while doing it?

The following example from a living field at Chuxiang Village of Lugu Township shows this process in action, as well as how using real-world observation as a basis for answering these questions is the key of design thinking.

For the current status of Lugu Township industrial culture waning, students conducted observations at the practical problems of Chuxiang Village, they discovered the facts: tea industrial management context and market positioning. With this insight, students started their research plan, heading out to these rural villages to learn more about technology services in context. Rather than trying to develop tea industries, they realized the true need was to evolve tourism for cultural experience and natural ecology, and user interface for mobile applications. The process employed Service Design for living field at Chuxiang Village is explained in Fig. 4. In doing so, they constructed a tea factory to be a smart living field, providing experiment fields for students, and spots of sceneries for the local tours.
Meanwhile, the Augmented Reality (AR) technologies were used to develop various activities for tourists, such as designing and implementing greeting cards with pattern flowers for Mother’s Days or Chinese Valentine’s Days (Lin et. al., 2014). Augmented Reality technologies by using “3D pattern with marked AR”, “Video playback with mark-less AR”, and “3D animation mark-less AR”, have been developing for tour projects. Fig. 5 explains the works designed by AR technologies and Table 1 summaries the developed AR technologies. Students implemented knowledge in information and communication field, and also gained the expertise of handicraft arts. While the local artists learned technologies of tendency, and assimilated easily into their design works.
3. Discussions

Cultural creation and ICT are two important industries in Taiwan, so that development of interdisciplinary course modules is necessary in cultivating students for multiple learnings. The SEE technology applied in double-sandwiched course module is proposed for students’ learning courses in this study, also is applied in designing and implementing for living field at Chuxiang Village of Lugu Township in Taiwan.

To encourage the learning motivation, the Service Experience Engineering activities are designed through the design thinking and training to create more values of rural villages. Through three-year co-work opportunities, students learn to work with local artists and design interactive tourism by using mobile application technology. Both students and local residents are really rewarded lots from the service design process.

Through three-year co-work opportunities, students learn to work with artists and design intelligent crafts by using AR technology. They participated in the project-based courses and experienced three different design patterns, including 3D static object, video playback, and 3D animations AR technologies.

4. Conclusion

In this work, a sandwiched course module based on Service Experience Engineering is introduced for students by progressive approaches with interdisciplinary learning of the smart living topics. It includes five hierarchies of courses from the elementary to the high-end courses. The course module has been running for four years from freshman to senior.
While students participated in these learning courses, they progressed significantly and accumulated valuable experiences especially when they worked together with local artists or technologists, since teaching and learning promote and enhance each other.

The use of Augment Reality application technology will be continued studying to achieve the integration of ICT industries and tourism for cultural experience in the future. It would be also focused on procedures of reflection and implementation in the service design thinking for the living field at Chuxiang Village.

Acknowledgements
The authors would like to thank the Ministry of Education of the Republic of China, Taiwan for financially supporting this report. More excellent comments of the anonymous reviewers are greatly acknowledged that have helped a lot in improving the quality and readability of the paper.

5. References
ASET - http://asetservices.com/services/research/
Chung, C.C. and Lin, C.M., “Double-Sandwiched Course Modules for Smart Living topics”, 2016 CSEDU, the International Conference on Computer Supported Education, accepted.
ICEAI-1048
Design of a Dual-Mode High-Efficiency Buck Converter for Portable Applications

Mei-Ling Yeh*, Zi-Chian Hong, and Yu-Chieh Cheng
Department of Electrical Engineering,
National Taiwan Ocean University, Taiwan, R. O. C.
mlyeh@mail.ntou.edu.tw

Abstracts
In recent years, the portable electronic devices market is flourishing quickly and product features tend to be diversification. The miniaturization of power management modules and improvement of conversion efficiency become the primary consideration. In this paper, we design a new dual-mode high-efficiency Buck converter which can operate in a high switching frequency and with a wide load range. When the current is at light loads, the converter operates in pulse skipping modulation (PSM) at discontinuous conduction mode (DCM); when the current is at heavy loads, the converter operates in pulse width modulation (PWM) at continuous conduction mode (CCM). Moreover, the power transistors have been divided into three parts, and according to the load current to open the relative power transistor parts. This design can achieve four load ranges, and optimize the switching loss to improve conversion efficiency, especially significantly improve the converter efficiency at light loads. This converter has been designed and implemented with TSMC 0.35 um 2P4M 5V Mixed-Signal CMOS process. With input voltage ranging from 3.0 to 4.2 V, the output voltage is steady in 1.8V. The switching frequency is 10MHz. The load current range can be 50 ~ 500mA. The conversion efficiency raises to 78% at light loads and the maximum conversion efficiency is 89.5% at heavy loads. The inductor is reduced to 1uH and the output capacitor is 10uF. This can effectively reduce external passive component size, and is suitable for portable products.

Keywords: Buck converter, PSM, PWM, Conversion efficiency

1. Introduction
The portable electronic device market continues to expand, from the laptops, cell phones to smart watches, more and more features are included. The requirements of the power management ICs become more complex and stringent. The sizes of power management modules and conversion efficiency become the key performance parameters. Furthermore, the switching frequency of the current voltage converters is ranged mostly between 500KHz to 2MHz, under the condition of 500mA output current, the inductance value generally ranges between 4.7μH ~ 10μH [1],[2]. The latest studies are towards improving the switching frequency in order to reduce the inductor size, but resulting in increase of switching losses,
especially at light loads. Therefore, in this paper we propose a novel 10MHz dual-mode high-efficiency Buck converter, which divide the power MOSFETs into three parts and can operate in pulse skipping modulation (PSM) at light loads, and in pulse width modulation (PWM) at heavy loads.

2. Current Mode DC-DC Buck Converter

The characteristic of a current mode buck converter is that it has two feedback paths. One feedback signal is the load current detected by the current sensing circuit. This signal needs slope compensation to avoid sub-harmonic oscillation. Another is the feedback voltage, which is the output voltage reduced by the feedback resistors. The error amplifier amplifies the error between feedback voltage and reference voltage. These two feedback signals are combined through the comparator to convert the analog signal into digital signal, which can modulate the duty cycle to control on and off of Power MOSFETs. Using this pulse width modulation to control the charging and discharging the inductor and capacitor, the output voltage will be stabilized. Fig. 1 shows the block diagram of a current-mode DC-DC buck converter.

Fig. 1. Block diagram of a current-mode DC-DC buck converter.

Fig. 2 shows the simulation results of conversion efficiency of the current-mode Buck converter with a switching frequency of 10MHz. From Fig. 2, we can see that the efficiency drops to 79% at load current of 100mA and when the current is 50mA, the efficiency even reduces to 66%. Therefore, when the PWM current-mode buck converter operates in high switching frequency, the low conversion efficiency problem at light loads is the primary research topic of the current power management chips.
3. Dual-Mode DC-DC Buck Converter with a Switch Controller

The pulse width modulation (PWM) has a better efficiency at heavy loads but poor efficiency at light loads, while the pulse skipping modulation (PSM) is the opposite [3]-[8]. Hence, we propose a novel dual-mode architecture to achieve high efficiency over a wide load range (50mA ~ 500mA). In order to switch modulation mode correctly under wide load current range, we use the current sensing circuit to detect the load current, and then send signal to mode selection circuit. When the current is at light loads, the converter operates in pulse skipping modulation (PSM) at discontinuous conduction mode (DCM); when the current is at heavy loads, the converter operates in pulse width modulation (PWM) at continuous conduction mode (CCM). Fig. 3 shows the block diagram of the proposed dual-mode DC-DC buck converter.

In addition to using the dual-mode structure, we also divide the power transistor into three small parts, as shown in the red color part of Fig. 3. Correspondent power transistors will be turned on according to different load currents. This design can further reduce the switching losses at light loads. Fig. 4 shows the conversion efficiency for different sizes of power MOSFETs. We divide the power transistor into three sizes of width 8000um, 10000um, and 30000um to achieve four operating ranges. The smallest block (A) is used in the minimum load range with PSM. The other blocks (B and C) are used with PWM. Block B and C are opened together at the heaviest load range, therefore the maximum size is 40000um.

Fig. 2. Efficiency of the Buck converter at 10MHz switching frequency.
From Fig. 4 we can know that the efficiency will increase because the switching losses are optimized by intelligent control to change the sizes of power transistors. By comparing with that of the single-size power transistor, the efficiency can significantly improve with this multi-size power transistor technique. This method increases the efficiency at light load of 50mA from 66% to 78%. Efficiency at heavy load of 500mA is still maintained at 89.5%. When the load current is in the range of 50mA~90mA, we turn on Power MOSFET block A and use pulse skipping modulation.
When the load current is in the range of 90mA~120mA and 120mA~150mA, pulse width modulation is adopted and block B and C are turned on, respectively. When the load current is greater than 150mA, we enable both block B and C and use pulse width modulation. The logic of switch controller is shown in Table 1.

<table>
<thead>
<tr>
<th>Current Range</th>
<th>(A) PSM 8000um</th>
<th>(B) PWM 10000um</th>
<th>(C) PWM 30000um</th>
</tr>
</thead>
<tbody>
<tr>
<td>50mA~90mA</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>90mA~120mA</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>120mA~150mA</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>150mA↑</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

4. Experimental Results

This buck converter is designed and fabricated with TSMC 0.35um 2P4M CMOS process. The external inductor is 1uH and the capacitor is 10uF. The overall efficiency is above 78% and the maximum efficiency is 89.5%. The load current range can be 50mA ~ 500mA. Fig. 5 is the waveform diagram of steady-state output voltage and clock signal. Seen from the figure, the output ripple voltage is 4.2mV and the switching frequency is 11.111MHz. Fig. 6 shows the line regulation simulation result. When input voltage increases from 3V to 4.2V, the output voltage changes 9.1 mV. According to the definition, line regulation is 7.5833mV/V, as calculated in Eq. (1).

$$\frac{\Delta V_{out}}{\Delta V_{in}} = \frac{9.1mV}{4.2V-3V} = 7.5833(mV/V)$$

(1)

Fig. 7 shows the logic waveform diagrams of switch controller when the load current is 50mA, 90mA, 120mA, 200mA and the input voltage is 3.6V. As seen from the figure, we can see the blocks are opened according to the different load currents. Opening sequence is block A ON, block B ON, block C ON, blocks B and C ON. Specifications table of this buck converter is presented in Table 2.
Fig. 5. Steady-state simulated results of the output ripple voltage and clock signal.

Fig. 6. Line regulation with input voltage from 3V to 4.2V.
5. Conclusions

In this paper, we propose a new dual-mode DC-DC buck converter. This converter is designed and implemented with TSMC 0.35 um 2P4M 5V mixed-signal CMOS process. By raising the switching frequency to 10MHz, the inductor size can be reduced to 1uH. It is favorable for microminiaturization of power management modules. Furthermore, we can reduce high switching loss at light loads in high switching frequency by using intelligently switching control of Power MOSFETs and dual-mode architecture, so that we can achieve the purpose of maintaining high efficiency over a wide load range. The overall load current range can be 50mA ~ 500mA. When the load current is 90mA or less, we adopt pulse skipping modulation (PSM). The efficiency can be maintained at more than 78%. When the load current is in the range of 90mA~500mA, we use pulse width modulation (PWM) with different sizes of power transistors. The maximum efficiency is 89.5%. This design helps to reduce the volume of the product, and to enhance the conversion efficiency. As a result, it is suitable for portable product applications.

Acknowledgments

The authors would like to thank National Chip Implementation Center of Taiwan for fabrication the chip. This work was supported by the Ministry of Science and Technology of Taiwan under grant MOST 104-2221-E-019 -014.
Table 2. Specifications of the buck converter.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process</td>
<td>TSMC 0.35µm</td>
</tr>
<tr>
<td>Frequency</td>
<td>10MHz</td>
</tr>
<tr>
<td>Supply Voltage</td>
<td>3–4.2V</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>1.8V</td>
</tr>
<tr>
<td>Load Current</td>
<td>50–500mA</td>
</tr>
<tr>
<td>Output Ripple(max)</td>
<td>&lt;5mV</td>
</tr>
<tr>
<td>Max. efficiency</td>
<td>89.5%</td>
</tr>
<tr>
<td>Inductor</td>
<td>1uH</td>
</tr>
<tr>
<td>Capacitor</td>
<td>10µF</td>
</tr>
<tr>
<td>Line Regulation</td>
<td>7.5833mV/V</td>
</tr>
</tbody>
</table>

References


ICEAI-1052

Modeling and Implementation of Adaptive Switched-Capacitor Step-Down DC-DC Converter for Piezoelectric Energy Harvesting

Yuen-Haw Chang
Department of Computer Science and Information Engineering,
Chaoyang University of Technology, Taiwan
cyhfyc@cyut.edu.tw

Chun-Hung Wang
Department of Computer Science and Information Engineering,
Chaoyang University of Technology, Taiwan
s10127609@gm.cyut.edu.tw

Abstract

This paper presents the modeling/implementation of an adaptive switched-capacitor converter (ASCC) for step-down conversion to piezoelectric energy harvesting. Its power part consists of two blocks: (i) Front: a bridge rectifier and a filter capacitor (Cᵢ), and (ii) Core: 5-stage serial-parallel SCC and an output capacitor (Cₒ). First, the front rectifier converts AC piezoelectric source into DC type, and harvests the energy to store in Cᵢ for building a DC voltage Vₛ. Then, the 5-stage serial-parallel SCC transforms Vₛ into 5 levels: Vₛ/5, Vₛ/4, Vₛ/3, Vₛ/2, or Vₛ for an adaptive multistage charging so as to protect the usage of battery load, especially for a lower battery voltage. Some theoretical analysis includes: formulation, steady-state analysis, stability, and total output response. Finally, the performance of ASCC scheme is simulated, and verified experimentally on the implemented prototype circuit, and the results are illustrated to show the efficacy of this scheme.

Keyword: piezoelectric energy harvesting, switched-capacitor converter (SCC), step-down conversion, adaptive multistage charging operation.

1. Introduction

With the rapid development of power electronics, the demand on voltage sources and types increases more, such as photovoltaic system (PV), piezoelectric energy, fuel cell...etc. Generally speaking, they need a harvester and/or converter to capture the energy and/or turn into the voltage available. For example, the piezoelectric device generates a high AC voltage (8~18V) much bigger than DC voltage of rechargeable batteries in common. Thus, a step-down converter combined with a rectifier is needed for energy harvesting. A SCC is one of good solutions to DC-DC conversion because it has only semi-switches and capacitors. Unlike traditional ones, the inductor-less SCC needs no magnetic element, so it has a light weight,
small volume, and low EMI. Up to now, many well-known types have been suggested [1]. In 1976, Dickson charge pump was proposed with a two-phase diode-capacitor chain [2]. In 1990s, Ioinovici et al. proposed a SCC with two symmetrical capacitor cells working at the anti-phase [3]. Zhu and Ioinovici performed a comprehensive steady-state analysis of SCC in 1997 [4]. In 2009, Tan et al. proposed the modeling/design of SCC by variable structure control [5]. Recently, Chang et al. proposed an integrated step-up/down SCC (SCVM/ D) [6], a SC-based boost inverter [7], and a gain/efficiency-improved serial-parallel SCC [8]. Here, for extending SC application, referring to Ottmann et al. proposed a piezoelectric energy harvesting circuit based on the booster [9], a closed-loop ASCC scheme as well as its modeling/implementation is presented for piezoelectric energy harvesting to achieve an adaptive multistage charging operation of battery load.

2. Configuration of ASCC

The overall configuration of a closed-loop ASCC is as in Fig.1 with two major parts: power part and control part. Fig. 2 shows the detailed logic circuit of the control part, composed of non-overlapping circuit and phase generator.

2.1 Power Part of ASCC

As in the upper half of Fig.1, the power part contains two: (i) a bridge rectifier and a filter capacitor $C_1$, and (ii) a 5-stage serial-parallel SCC and an output capacitor $C_o$, connected in cascade between the piezoelectric device and battery load. This bridge rectifier with 4 diodes $D_1-D_4$ is combined with $C_i$ to rectify a high AC volatge of piezoelectric device for building a DC supply $V_S$. This SCC contains 5 serial-parallel capacitors $C_1-C_5$, 7 switches $S_1-S_5,S_o$, one $C_o$, and 8 diodes $D_5-D_{12}$, to convert the DC $V_S$ into 5 different levels: $V_S/5,V_S/4,V_S/3,V_S/2,V_S$ for the adaptive multistage charging of battery. Here, assume each switch has the same on-resistance $r_T$, and each diode has the same on-resistance $r_D$. Compared to $V_S$, assume the cut-in voltage of diode is smaller enough to be neglected. Each serial-parallel capacitor has the same capacitance $C$ ($C_1=C_2=C_3=C_4=C_5=C$) with the same value of equivalent series resistance (ESR) $r_C$. So, the voltage across these capacitors can be treated as identical and denoted by $V_C$. Fig. 3 shows the theoretical waveforms of ASCC. Here, the total charging operation is scheduled for five stages (Stage I, II, III, IV, and V) according to 5 different levels of $V_S$ so as to protect the usage of the battery, especially for the lower battery voltage. Here, each stage contains many switching cycles of $T_S$ ($T_S=1/f_S$, $f_S$: switching frequency). In each $T_S$, there are two symmetrical phases: charging capacitors in series (Phase I: $\phi_1=1, \phi_2=0$) and discharging capacitors in parallel (Phase II: $\phi_1=0, \phi_2=1$), where $\phi_1, \phi_2$ is a set of non-overlapping anti-phase signals with the same phase cycle $T_S/2$. The operations of these five stages are described as follows. (i) Stage I: ($0 \leq V_o < V_S/5$) In Phase I, turn on $S_1,S_5$, and off $S_o,S_1-S_4$. Then, $D_5-D_8$ are on, and $D_0-D_{12}$ are off. The current-flow path is as “—“ in Fig. 4(a). $C_1-C_5$ are charged in series by $V_S$. In Phase II,
$C_1 - C_5$ are discharged in parallel to transfer the energy into $C_o$ and battery load $C_{Bat}$. The current-flow path is as “---“ in Fig. 4(a). Via the cyclical phases, $V_o$ raises up towards $V_S/5$ ($n$ is defined as the SC step-down ratio, i.e. the working capacitor count is $n=5$ now). (ii) Stage II: ($V_S/5 \leq V_o < V_S/4$) In Phase I, turn on $S_1,S_4$, and off $S_0,S_1 - S_3,S_5$. $D_5 - D_7$ are on, and $D_8-D_{12}$ are off. The current-flow path is as “—“ in Fig. 4(b). $C_1 - C_4$ are charged in series by $V_S$. In Phase II, $C_1-C_4$ are discharged in parallel to transfer the energy into $C_o$ and $C_{Bat}$. The path is as “---“ in Fig. 4(b). $V_o$ is getting up from $V_S/5$ to $V_S/4$ ($n=4$). (iii) Stage III: ($V_S/4 \leq V_o < V_S/3$) In Phase I, turn on $S_1,S_3$, and off $S_0,S_1,S_2,S_4,S_5$. $D_5,D_6$ are on, and $D_7-D_{12}$ are off. The current-flow path is as “—“ in Fig. 4(c). $C_1-C_3$ are charged in series by $V_S$. In Phase II, $C_1-C_3$ are discharged in parallel to transfer the energy into $C_o$ and $C_{Bat}$. The path is as “---“ in Fig. 4(c). $V_o$ is getting up from $V_S/4$ to $V_S/3$ ($n=3$). (iv) Stage IV: ($V_S/3 \leq V_o < V_S/2$) In Phase I, turn on $S_1,S_2$, and off $S_0,S_1,S_3-S_5$. Then, $D_5$ is on, and $D_6-D_{12}$ are off. The current-flow path is as “—“ in Fig. 4(d). $C_1-C_2$ are charged in series by $V_S$. In Phase II, $C_1-C_2$ are discharged in parallel to transfer the energy into $C_o$ and $C_{Bat}$. The path is as “---“ in Fig. 4(d). $V_o$ is getting up from $V_S/3$ to $V_S/2$ ($n=2$). (v)
Stage V: \( V_S / 2 \leq V_o < V_S \) In Phase I, turn on \( S_1, S_2 \) and off \( S_0, S_2 - S_5 \), and then \( D_5 - D_{12} \) are off. The current-flow path is as “—” in Fig. 4(e). \( C_1 \) is just charged by \( V_S \). In Phase II, \( C_1 \) are just discharged to transfer the energy into \( C_o \) and \( C_{Bat} \). The path is shown as “---” in Fig. 4(e). \( V_o \) is getting up from \( V_S / 2 \) to \( V_S \) \((n = 1)\). Based on this multistage charging, \( V_o \) across the battery is raising up towards \( V_S \) stage by stage. It helps the battery not only to harvest the piezoelectric energy, but also to avoid the large peak charging current at the load for the protection of battery, especially when the battery is with a lower voltage.

### 2.2 Control Part of ASCC

The control part as in the lower half of Fig. 1 is composed of a non-overlapping circuit and a phase generator, and its detailed logic circuit is as in Fig. 2. Their functions are described as follows. (i) The non-overlapping circuit generates a set of non-overlapping anti-phase signals \( \phi_1, \phi_2 \) for realizing the charging and discharging operations as above. (ii) This phase generator consists of a voltage divider, voltage
 comparator, and AND logic gates so as to generate the switch driver signals $S_1 - S_5$ according to $V_S$ and $V_o$. First, from the view of signal flow, the signal of $V_S$ is sent into the voltage divider to produce five different divisions as: $V_S/5, V_S/4, V_S/3, V_S/2, V_S$. And then, the signal of $V_o$ is compared with these divisions by using the voltage comparator to produce a set of the control signals: $S_{v5}, S_{v4}, S_{v3}, S_{v2}, S_{v1}, S_{off}$. Finally, via some AND logic gates, these control signals are synchronized with the help of the signal $S_i$ so as to obtain the switch driver signals $S_1 - S_5$. Here, the signal $S_i$ is generated by $\phi_1$ and $S_{off}$ to control the energy transferring from the piezoelectric device to the SC bank, and $S_o$ is generated by $\phi_2$ and $S_{off}$ to control the energy transferring from the SC bank to the battery load (If $V_o > V_S$, then $S_{off} = 1$ leads to stop $S_i$ and $S_o$). Based on the design, this control part can generate these switch driver signals ($S_1 - S_5, S_i, S_o$) exactly like the theoretical waveforms in Fig. 3 for achieving the adaptive multistage charging operation of battery load.

3. Formulation of ASCC

First, according to the Stage I-V topologies as in Fig. 4, the total equivalent circuits with respect to Phase I and II can easily be obtained as in Fig. 5(a)-5(b), where the battery is taken as the model: a capacitor $C_{Bat}$ connected with a large resistor $R_P$ in parallel and then in series with a small resistor $R_S$. Here, $R_S$ is assumed small enough to be neglected for the high-quality battery. Based on Fig. 5, the relevant differential equations for Phase I and II can be derived as: $(\bullet)' = d(\bullet)/dt$
(i) Phase I: (Fig. 5(a))

\[ V_C(t) = \frac{V_S(t) - n \cdot V_C(t)}{R_A C}, \quad V_{0B}(t) = \frac{V_{oB}(t)}{R_{PB} C_{oB}}, \quad V_o(t) = V_{oB}(t). \]  

\[ (1a,b,c) \]

where \( R_A = 2r_T + n \cdot r_C + (n-1) \cdot r_D \), \( R_B = r_T + r_C/n + 2r_D \) are the parasitic resistances. \( V_{oB}(t) \) is the capacitor voltage across the integrated capacitor \( C_{oB} = C_o + C_{Bat} \). Based on (1)-(2), by using state-space averaging (SSA) technique, i.e. \([1] + [2])/2\), the state-space equation of ASCC as running \( n \) can be derived as:

\[ x'(t) = A_n \cdot x(t) + B_n \cdot u(t) \quad y(t) = C_n \cdot x(t), \]  

where \( x(t) = [V_C(t) \quad V_{oB}(t)]^T \quad y(t) = [V_o(t)] \), \( u(t) = [V_S(t)] \),  

\[ (3a,b) \]

\[ A_n = \begin{bmatrix} \frac{-n^2}{2nC(R_A + R_B)} & \frac{-1}{2nR_gC} \\ \frac{1}{2R_B C_{oB}} & \frac{-1}{C_{oB}(R_P + 2R_B)} \end{bmatrix}, \quad B_n = \begin{bmatrix} \frac{1}{2R_A C} \\ 0 \end{bmatrix}, \quad C_n = [0 \ 1]. \]  

\[ (4a,b,c) \]

Firstly, the steady-state analysis is discussed. According to (3), the transfer function \( T(s) \) between \( V_o \) and \( V_S \) as running \( n \) can be derived as:

\[ T(s) = \frac{V_o(s)}{V_S(s)} = C_n(sI - A_n)^{-1} B_n - \frac{1}{4C_{oB} R_A R_B \cdot \Delta(s)}, \]  

\[ (5a) \]

\[ \Delta(s) = s^2 + \frac{1}{2nC(R_A + R_B)} + \frac{1}{C_{oB}(R_P + 2R_B)} + \frac{1}{2nC_{oB} R_A} + \frac{1}{2R_A R_B}. \]  

\[ (5b) \]

By substituting \( x' = 0 \) of (5), the steady-state value of \( V_o \) is obtained as in (6), i.e. the final value of \( V_o \) in the time interval of Stage \( 6-n, \ n = 5,4,3,2,1 \).

\[ V_o = \frac{R_P}{R_P - 2(R_A/n^2 + R_B)} \cdot \frac{V_S}{n} \cdot \frac{\Delta_n}{n} \cdot \frac{V_S}{n}. \]  

\[ (6) \]
If \( R_p > R_A, R_B \), then \( h_n \approx 1 \), i.e. the final value of \( V_0 \) is really close to \( V_S/n \). In general, \( R_p \) is about in k\( \Omega \) level, and \( r_T, r_C, r_D \) of \( R_A, R_B \) are in \( \Omega/m\Omega \) level.

Secondly, the stability of ASCC is discussed. The system matrix \( A_n \) of (4d) can be divided into 4 sub-matrices \( A_{11} - A_{22} \), and decomposed as in (7a), where \( \Delta_n \) is obtained as (7b).

Clearly, the stability depends on the poles of \( A_{11} \) and \( \Delta_n \).

\[
A_n = \begin{bmatrix}
A_{11} & A_{12} \\
A_{21} & A_{22}
\end{bmatrix} = \begin{bmatrix}
I & 0 \\
A_{11}^{-1} & I
\end{bmatrix} \begin{bmatrix}
A_{11} & 0 \\
0 & \Delta_n
\end{bmatrix} \begin{bmatrix}
I & A_{11}^{-1}A_{12} \\
0 & I
\end{bmatrix},
\]

(7a)

\[
\Delta_n = A_{22} - A_{21}A_{11}^{-1}A_{12} = -1/[(R_p||2(R_A/n^2 + R_B)) \cdot C_{oB}] = -1/\tau_n.
\]

(7b)

According to Fig. 5(a), the time constant of charging from \( V_S \) to SC bank is \( R_A C/n \). For the fast response, this value is taken smaller than \( T_S/2 \) (i.e. \( R_A C/n < T_S/2 \)). Normally, \( C_{oB} \) is many times larger than \( C \). Thus, because \( C_{oB} \) in \( \Delta_n \) is much larger than \( nC \) in \( A_{11} \) of (4d), it is obvious that \( \Delta_n \) is the dominant pole of ASCC. Since \( \Delta_n \) is in the left half of s-plane, this converter is locally stable.

Thirdly, the output response is discussed. Based on (7b), the output response for each stage can be modeled by a simple RC model as: \( V_o(t) - V_o(\infty) + [V_o(0) - V_o(\infty)] e^{-t/\tau_n} \), where \( V_o(\infty), V_o(0) \) are the final/initial value. With the help of (5) for \( V_o(\infty), V_o(0) \), the total output response of \( V_o(t) \) can be derived as in (8). It is found that the result in the multistage operation is a staircase-alike RC charging stage by stage so as to protect the battery as well as extend the lifetime.

\[
V_o(t) = \begin{cases} 
  h_S \frac{V_S}{s}, & n = 5 \text{ [Stage I]} \\
  h_n \frac{V_S}{n}, & n = 4, 3, 2, 1 \text{ [Stage II-III IV V]} 
\end{cases}
\]

(8)

4. Examples of ASCC

In this section, a closed-loop ASCC is simulated by OrCAD Pspice tool, and its hardware is implemented and tested. In the beginning, based on Fig. 1, the ASCC is designed by PSpICE for simulation, and the main function is to harvest the energy from the piezoelectric device into the battery load based on the adaptive multistage charging operation. The circuit parameters are listed as: \( C = 0.5 \mu F \), \( C_1 = C_0 = 500 \mu F \), \( C_{Bank} = 1 mF \), \( R_P = 1 \Omega \), \( r_T = r_D = 0.1 \Omega \), \( r_C = 0.2 \Omega \).
\( f_0 = 20\, \text{kHz} \). Firstly, the simulation is discussed as follows. (i) Case I: Assume that \( V_S \) is 18V, and then the closed-loop ASCC is simulated. The waveform of \( V_o \) within 6.5 sec is obtained as in Fig. 6(a). Obviously, \( V_o \) is raising stage by stage (Stage I→II→III→IV→V) to get close to \( V_S \). After 5.88 sec, the operation starts entering the Stage OFF to stop the charging operation, and the battery voltage is about 17.28V now. (ii) Case II: Assume that \( V_S \) is 18V, and it has a sudden voltage drop down to 0V from 0.5 sec to 2 sec (i.e. \( V_S = 18V \rightarrow 0V \rightarrow 18V \)). Fig. 6(b) shows the total waveform of \( V_o \) within 8 sec. Obviously, the voltage level of \( V_o \) stops raising to hold at 3.4V during the time interval of \( V_S = 0V \). The current stage is turning from Stage II into Stage OFF to pause the charging operation for adapting this supply variation. When \( V_S \) recovers back to 18V after 2 sec, \( V_o \) keeps going back to the charging operation.

Secondly, the experiment is discussed as follows. The hardware of ASCC is realized as the photo in Fig. 7: (i) Power part (left: 15cm × 9cm), (ii) Control part (right: 15cm × 9cm). The prototype circuit parameters are listed as: \( C = 4.7\, \mu\text{F} \), \( C_1 = C_2 = 22\, \mu\text{F} \), \( C_{\text{Bat}} = 10\, \text{mF} \), \( R_p = 2\, \Omega \), \( r_T = 0.3\, \Omega \), \( r_D = 0.3\, \Omega \), \( r_C = 0.5\, \Omega \), \( f_0 = 20\,\text{kHz} \). Here, this piezoelectric device (3 pieces, 6cm × 2cm/piece, type: SB4020008, Superex Tech.) is driven for a frequent vibration by the extra electromagnetic mechanism so as to build a practical supply \( V_S \) of 9.6V, and then the hardware of closed-loop ASCC is tested. The waveforms of \( V_o \) through the different stages are measured practically as in Fig. 8(a)-8(e) (Tool: Agilent Tech. MSO-X 3052A oscilloscope and LabVIEW 2013 software). By integrating the measurements of \( V_o \) versus time, the total output response can be obtained as in Fig. 8(f). Clearly, \( V_o \) is raising through Stage I→II→III→IV→V to
Fig. 6. Simulation waveforms of $V_o$ for Case (a) I, and (b) II.

Fig. 7. Prototype circuit of closed-loop ASCC.
get close to $V_S$. After 165 sec, the operation starts entering the Stage OFF to stop the charging operation, and the battery voltage is about 9.4V now.

4. Conclusions

This paper presents the modeling and implementation of an ASCC for step-down conversion to piezoelectric energy harvesting. In this paper, some theoretical analysis includes: formulation, steady-state analysis, stability, and total output response. Finally, the performance of this scheme is simulated, and verified experimentally on the ASCC prototype, and the results are illustrated to show the efficacy of this scheme. The advantages of the proposed scheme are listed. (i) An adaptive multistage charging operation is suggested so as to protect the usage of battery load, especially when the battery is with a lower voltage. (ii) The ASCC belongs to the SC circuit, so it needs no magnetic element (inductor/transformer). The fabrication of ASCC is promising in the future. (iii) In the control part, the phase generator with changing the stage number adaptively is designed for being able to adapt the supply variation.
Acknowledgment
This converter circuit theory and application is financially supported by Ministry of Science and Technology of Taiwan, R.O.C., under MOST 104-2221-E-324-015.

References


A Robust Mel-Bands Audio Fingerprint Based on Spectral Local Maximum Energy for Content Based Copy Detection

F. Yuan, L.M. Po, L. Feng, Y. Li
Department of Electronic Engineering, City University of Hong Kong, China
Email: iyuanyang0105@gmail.com

X. Xu
Tencent Video Group, Tencent, China

Abstract
The acoustic information has become more and more attractive in content based copy detection system. Recently, audio fingerprint technology has been considered as an important alternative to meet the copy detection challenge due to its low computational complexity as compared with traditional usage of visual information. In this paper, a novel audio fingerprinting algorithm is proposed which is based on Spectral Local Maximum Energy and Mel-Bands (SLME-MB). In addition, a special improved Hash searching scheme is proposed to refine the traditional retrieval framework, which could be used in more realistic application with balanced consideration on precision of detection and false positive rate (FPR). The proposed algorithm is evaluated with use of TRECVID2010 dataset in 13 different types of distortion. The experimental results show that the proposed audio fingerprint algorithm is very robust against most of distortions, even some high challenge cases, such as broadcasting transmission simulation, real noise environment, and speed change. Moreover, the proposed searching scheme using threshold 1 could decrease the FPR to about 10% and the refined threshold 2 could increase the ROC performance by about 1%.

Keywords: Audio fingerprint, spectral local maximum energy, multimedia, content based copy detection

1. Introduction
Recent rapid development of wireless communication and smart device has created a great challenge about multimedia copy issue to internet companies, like YouTube, Youku, etc. Meanwhile, the commercial profit of content identification and recommendation is also considerable and attractive to motivate people to find the efficient method of multimedia copy detection. Generally, the problem of copy detection should be defined as “how to efficiently identify the clips with copyright issue, and locate the position of copied clip in the reference file”.
In the last decade, multimedia fingerprint technology was considered as most efficient approach for content-based copy detection (CBCD), in which the extracted fingerprint is compact and informative representation of the multimedia content. There are two types of fingerprint according the different of origin: intrinsic fingerprint (called natural fingerprint) extracted from the multimedia itself and extrinsic fingerprint inserted or embedded into multimedia artificially. The traditional extrinsic fingerprint is watermarking[1]. Basically, there are two sources of fingerprint can be extracted from digital multimedia content in form of audio and visual information. Well-known visual fingerprint algorithms for CBCD can be found in [2][3][4]. However, computational complexity and memory requirements of visual information based fingerprinting algorithms are normally much higher than audio based fingerprinting methods, which making audio fingerprint very attractive for practical CBCD system implementation. In addition, audio fingerprinting can also achieve very good performance in terms of accuracy and robustness on different types of distortion. For example, Haisma et al.[5] proposed a frequency domain audio fingerprint extraction and hash indexing framework for CBCD applications, which has been adopted in many real systems such as [6]. The Bark-scale[5] or equal bands[7] is adopted to divide the frequency direction into several bands in generation of binary fingerprint. In order to avoid the errors introduced by binary coding(lossy compression), the Bit Error Rate[5] is adopted as a metric. A fingerprint based on multiple 2-D spectrums was proposed by C. Ouali, et al.[7] to suppress noise affection to fingerprint, and got an improved performance in noised case. In a following work, W. Son, et al.[8] proposed a robust audio fingerprint according the Predominant Pitch Estimation (PPE), the bits which only fall into the PPE region could be taken as valid bits, otherwise the others bits should be set as zeros. The algorithm of W. Son can achieve good performance in noised case on smart device application, while the procedure of fingerprint generation according PPE essentially is the recompression, and it is a more lossy compression.

On the other hands, the algorithm of A. Li-Chun Wang [9] achieved commercial success in the application of song identification and recommendation. The fingerprint(called landmark) is generated between two relative anchor points. H. Kim, et al.[10] introduced the Modulated Complex Lapped Transform (MCLT) to instead the STFT in procedure of Time-Frequency transformation, and it can get the good performance in extreme noised environments. In order to get more representative and stable salient peak in spectrum, X. Pan, et al. [11] proposed a fingerprint based on Local Energy Centroid (LEC), which is a representation of energy conglomeration degree in a small region of spectrum. The high computational load is the main problem of this algorithm as the three times refining should be carried out to find the LEC location.

Therefore, selecting more representative salient peaks in spectrum and reducing the compression errors in coding procedure have become the common and inevitable problems to
researchers and engineers. In this paper, we proposed a novel audio fingerprint based on Spectral Local Maximum Energy and Mel-Bands (SLME-MB), and the state-of-art algorithms (short denotation as JH[5], WS[8], Wang[9], and XP[11]) are used for comparison.

For the hash searching, it is general and ordinary that a query is tested with no copy issue in copy detection system. However, the searching scheme used in existed algorithms [5][8][9][11], which mostly are based on maximum likelihood of similarity between query and reference file, has the high False Positive Rate (FPR) problem as matched rate is more important indicator in identification and recommendation application. Therefore, we proposed a special improved scheme of hash searching, which could be used in more realistic application with balanced consideration on precision of detection and false positive rate, to refine the traditional retrieval framework.

The remainder of this paper is organized as follows: Section 2 describes the proposed algorithm with new audio fingerprint algorithm and special improved searching scheme. Section 3 introduces the database used in this paper, and discusses the experimental results. Finally, Section 4 gets the conclusion of this paper.

2. Proposed Algorithm

A typical CBCD system, as shown in Fig. 1, is comprised of offline and online processes. In the offline process, the reference multimedia database is formed by pre-storing the extracted fingerprints from reference files. In the online process, the fingerprints of the query are extracted as the same way and the Hash is used for searching the database. Finally, the searching result is generated and returned according the scoring strategy.

![Fig 1. Overview of fingerprint based copy detection system](image)

2.1. Audio Fingerprint Based on Spectral Local Maximum Energy and Mel-Bands (SLME-MB)

The overview of proposed audio fingerprint algorithm based on SLME-MB is shown in Fig. 2. There are mainly five steps of the proposed audio fingerprint algorithm. Firstly,
the audio signal’s spectrum is computed using Short Time Fourier Transformation (STFT). The well-known hamming window is adopted with window size of 0.4 seconds, and 0.38 seconds overlapping. It turns out that this overlapping can resist some distortions, such as nosing, and speed change. Secondly, compared with JH[5] in which the original spectrum is divided into some bands, the Local Maximum Energy (LME) is extracted to represent the original spectrum. There will be some pseudo energy peak in the spectrum because of corruption of some distortions like nosing, but the LME has the robust ability to keep its location and outstanding character. Therefore, this can make sure the selected salient peaks to be the representative peaks as much as possible. Thirdly, the Mel-scale (Mel-bands) [12] is adopted to reduce the redundant information of spectrum according the Human Hearing System (HHS) [13]. Generally, the ability of HHS is ranged between 200 Hz and 2000 Hz, the component of others frequency bands actually are lost by HHS. Moreover, the useful information typically concentrate in low frequency of audio spectrum. Therefore, the 16 bands are divided from 200 Hz to 2000 Hz according Mel-bands. The relation of Mel-bands and frequency in Hertz is defined as [12] in eq. 1.

\[ Mel = 2595 \times \log_{10}(1 + \frac{Hertz}{700}) \]  

(1)

Fourthly, the coding is implemented to generate bit string fingerprint. Through banding of frequency according Mel-bands, there are 16 bands of frequency for each frame, the n×16 spectral matrix will be formed by calculating the sum of energy in each band. Then we use a sign function to code the banded spectral matrix, the sign function is shown as eq. 2.

\[ f(n, m) = \begin{cases} 
1 & \text{if } E(n, m) - E(n, m+1) \geq 0 \\
0 & \text{if } E(n, m) - E(n, m+1) < 0 
\end{cases} \]

(2)

where, n,m are the frame number and bands number, respectively, E is used to represent the energy of location (n,m).
This differential coding can efficiently keep the detail and variation tendency of banded spectral information, because we use the LME to generate a more represented and robust audio spectrum, it means that the generated spectrum is very compact and informative, we should code this spectrum using a much lesser lossy way. However, some well-known coding method like triangle coding [5] output the one bit using four elements in spectrum, it will lost many useful information, especially in some compact spectrum like LME. Finally, we use the Hash to build a database, and the key is a certain fingerprint in the query, value is ID of query and the location of this fingerprint. The structure of Hash is <key(binary feature), value(ID,locs)>, like <0X3625,(3,321)>. 

2.2. Searching Scheme

Searching is another task of copy detection system, the structure of invert index file has become very popular in the copy detection area. The overview of database searching is shown as Fig. 3. The main procedure of existed searching strategy is BER comparison between the candidate reference file and the query, if not matching, the offset will be increased one, and the length of matching query will also be decreased one until the offset equal the length of query fingerprints in the extreme case. While, we find that BER criterion will become meaningless when we take the FPR into account, because the FPR will increase dramatically when the offset is large than a specific Threshold (TS1: a multiple of the length of query fingerprint). Therefore, we adopt the TS1 as the first optimizing parameter, if the offset is large than the TS1, the result will be fed back, otherwise, the BER comparison will be implemented.

On the other hand, there is a tradeoff between TS1 and ROC (Precision and Recall) performance, we chose another threshold (TS2) to make up for the decrease of ROC because of FPR consideration. Actually, the BER can’t guarantee the accuracy of detection because the fingerprints clip is too short to compare the BER when the offset is larger than the TS1. Contrarily, the occurrence of specific reference file in the previous matching rounds will
represent the truth. Therefore, the TS2 is adopted to refine the detection result, if the some clip has the maximum occurrence in all candidate reference files, and its occurrence is larger than the TS2, it will be chosen as matched file. The overview of proposed searching scheme is shown in the Fig. 4.

3. Experimental Results

3.1. Database and Evaluation Metrics

In this paper, we evaluate the performance of the proposed algorithm using a database based on TRECVID2010 [14], the RECVID2010 dataset is released for the campaign of TREC conference, held by NIST. The simulated database is composed of two parts, about 4,200 reference audios extracted from reference video collection, totally about 158 hours, 90GB, and two testing dataset are respectively generated from 122 and 162 original queries by implementing 13 different distortions. For original queries, it consists of 2 types: a segment of reference file (122) and a segment of nonreference (40) that is not in the reference dataset. Table 3 shows the types of distortions. And the Table 4 shows the detail of two testing dataset (Query1 and Query2). There are two evaluation metrics adopted in this paper, ROC (Precision and Recall) and False Positive Rate (FPR).
The performance of proposed fingerprint algorithm is evaluated using Query1 (same searching strategy with the state-of-art algorithms [5][8][9][11]) in terms of Precision, and the proposed special improved searching scheme is evaluated using Query2 in terms of ROC and FPR.

### 3.2. Result Analysis

The precision of detection and localization is evaluated. As the Table 5 and Fig. 4 shown that the proposed fingerprint algorithm has the best performance in total 12 types of distortions, even some high challenge cases, such as broadcasting transmission simulation (D10), real noise environment (D11), and speed change (D12~13). Moreover, it has a stable performance in some common distortions, like noise cases from D6 to D9. The precision of localization is shown as Table 6 and Fig. 5. We can recognize that the precision of localization is very similar with the precision of detection, and the proposed algorithm has a best performance in 6 kinds of distortions. It is worth to mention that the performance of Wang’s algorithm is the best in the noise distortion with SNR -3dB, and it has a stable precision in the noise case.
The above evaluation of detection and localization precision has turned out that the proposed audio fingerprint has a robust and good character in many distortions. And then, the Testing Query 2 is used to evaluate the new searching scheme. ROC and FPR is adopted as the evaluation metric. As mentioned in the part 2, there is a tradeoff between TS1 and ROC, the proper threshold1 should be selected. The Fig. 6 shows the relation between threshold 1(TS1) and ROC with experiment result. As the Fig. 6 illustration, the proper selection of TS1 should be about 0.8, because the value in this range can make both precision and recall into account. As TS1 will introduce some decrease in performance of ROC if we want to keep low FPR, therefore, we introduce threshold 2(TS2) to make up for the decrease of ROC because of FPR consideration. The TS2 is a factor of occurrence of certain reference file in the candidates of searching, it could be an experimental and empirical value according the scenario of real application. In this paper, we select the 0.5 as TS2. And the final performance of proposed searching scheme is shown in the Fig. 7. We can recognize that the original scheme used in the state-of-art algorithms cannot deal with the FPR problem, however, the proposed algorithm can get very low FPR by adopting the TS1 and TS2, concretely, the FPR decrease by about 90%, and to about 10%. TS2 can further enhance the ROC performance in consideration of low FPR, the ROC can slightly increase by about 1%.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>D1</td>
<td>0.992</td>
<td>0.983</td>
<td>0.941</td>
<td>0.992</td>
<td>0.992</td>
</tr>
<tr>
<td>D2</td>
<td>0.797</td>
<td>0.805</td>
<td>0.814</td>
<td>0.983</td>
<td>0.983</td>
</tr>
<tr>
<td>D3</td>
<td>0.780</td>
<td>0.737</td>
<td>0.703</td>
<td>0.975</td>
<td>0.966</td>
</tr>
<tr>
<td>D4</td>
<td>0.839</td>
<td>0.686</td>
<td>0.508</td>
<td>0.966</td>
<td>0.966</td>
</tr>
<tr>
<td>D5</td>
<td>0.636</td>
<td>0.508</td>
<td>0.636</td>
<td>0.873</td>
<td>0.898</td>
</tr>
<tr>
<td>D6</td>
<td>0.949</td>
<td>0.958</td>
<td>0.847</td>
<td>0.966</td>
<td>0.966</td>
</tr>
<tr>
<td>D7</td>
<td>0.907</td>
<td>0.915</td>
<td>0.780</td>
<td>0.949</td>
<td>0.958</td>
</tr>
<tr>
<td>D8</td>
<td>0.864</td>
<td>0.754</td>
<td>0.525</td>
<td>0.856</td>
<td>0.856</td>
</tr>
<tr>
<td>D9</td>
<td>0.847</td>
<td>0.525</td>
<td>0.415</td>
<td>0.763</td>
<td>0.763</td>
</tr>
<tr>
<td>D10</td>
<td>0.653</td>
<td>0.424</td>
<td>0.568</td>
<td>0.856</td>
<td>0.881</td>
</tr>
<tr>
<td>D11</td>
<td>0.525</td>
<td>0.297</td>
<td>0.373</td>
<td>0.661</td>
<td>0.593</td>
</tr>
<tr>
<td>D12</td>
<td>0.220</td>
<td>0.017</td>
<td>0.008</td>
<td>0.466</td>
<td>0.865</td>
</tr>
<tr>
<td>D13</td>
<td>0.212</td>
<td>0.068</td>
<td>0.017</td>
<td>0.686</td>
<td>0.864</td>
</tr>
</tbody>
</table>
4. Conclusions

In this paper, a novel audio fingerprint based on Spectral Local Maximum Energy and Mel-Bands (SLME_MB) is proposed. In addition, a special improved hash searching scheme is also proposed to refine the traditional searching framework, which could be used in more realistic application with balanced consideration on precision of detection and false positive rate. Experimental results show that it can achieve very robust performance in most of audio distortions and can keep the low FPR at about 10%. With use of the refined threshold 2, it can
further enhance the ROC about 1%. It turns out that the proposed algorithm could be used into more realistic content based copy detection system.

5. References


ICEAI-1076
Directional Acoustic Vibration Sensor Based on an Anisotropic Flat-Clad Tapered Fiber

Wei-Ren Wu, Chih-Yu Chen and Cheng-Ling Lee*
Department of Electro-Optical Engineering, National United University, Taiwan
E-mail address: cherry@nuu.edu.tw

Abstract
In this paper, we propose a low cost, compact and sensitive directional acoustic vibration sensor based on an anisotropic flat-clad tapered fiber (AFCTF). The proposed fiber device is fabricated by a flat-clad fiber (FCF) taper that is inserted into the glass capillary tube to form a rigid sensing structure of vibration. Measurement of surrounding vibrations by monitoring the periodical optical power of the proposed sensor is obtained. Experimental results show favorable responses to the surrounding vibrations with their corresponding directions of horizontal and vertical. The reported directional acoustic vibration sensor has been demonstrated that it can simultaneously and effectively indicate the directions, and sensitively measure the magnitude of vibrations.

Keywords: Flat-clad fiber, directional, vibration sensor, acoustic vibration, fiber-optic sensor.

1. Introduction
Methods of measurement that are based on fiber optics have attracted many interests because of the uniquely non-electrical operation of the fiber, compact optical wave-guiding and the fact that optical sensing can be performed over a long distance. In the sensing technology, vibration sensors are necessary for nondestructive inspection of civil infrastructures, structure health of large scale buildings, environmental surveillance and monitoring the operation of machines. There are many fiber-optic vibration sensors have been reported to effectively detect the vibration from the surroundings. Among the above studies, intensity-based fiber vibration sensors are simple and reliable [1-6]. Simple single-mode fiber (SMF) tapers have been reported to be the optical fiber acoustic vibration sensors. The vibrations can be simply detected by direct measurement of the SMF taper’s transmission power [1-2]. Another work for the acoustic vibration sensing is based on a pair of tapered fiber plugs that are bridged inside a very tiny section of hollow core fiber (HCF). Herein, a pair of arc-shaped tapered fiber plugs are inserted face to face into a tiny section of HCF and fused inside. The sensor can convert vibration signals into easily detectable optical power variations that can be measured [3]. The well-known fiber-based sensor for sensing vibration is based on optical fiber Bragg gratings (FBGs). The FBG sensors measure vibration by intensity modulation of incident light when the Bragg reflection wavelength shifts caused by applying sound pressure [4].
Another work for vibration sensing is based on in-line multimode fiber interferometers [5-6]. The above fiber-optical sensors effectively measure the vibration frequency using different sensing configurations, but they cannot efficiently determine the direction of the vibration since the fiber has cylindrical symmetry.

In this study, a simple, cost-effective and highly sensitive acoustic vibration sensor based on an anisotropic flat-clad tapered fiber (AFCTF) is experimentally investigated. The sensing element is shown in Fig. 1. The AFCTF vibration sensor can convert vibration signals into easily detectable optical power variations and also can indicate the vibration with horizontal (X-axis) or vertical (Y-axis) directions. In this work, the vibrations that are generated by an acoustic speaker can be simply detected by directly measuring the transmission power of the sensor. Then the time domain transmission power signal is collected and converted to a frequency spectrum through the fast Fourier transform.

![Fig. 1: The proposed AFCTF vibration sensor.](image)

2. Experimental

The original flat-clad single-mode fiber has a cylindrical core with diameter of 8.8 μm and a flat cladding with the diameters of 126 μm and 81.5 μm at long and short axes, respectively. The AFCTF was manufactured by using a self-designed electrical arc setup. The flat-clad fiber (FCF) was heated by an arc discharge and was then quickly elongated by a pair of translation stages. Because of the narrow hot-zone and fast stretching during manufacturing, the fabricated taper has an abrupt taper angle and a compact size. The fiber taper was fabricated simply using an Ericsson FSU-975 commercial fusion splicer, and as it does not rely on any particular tapering station or precise optical stages. Given an appropriate arc power, arc duration, and stretching distance, the diameter of the fiber was sharpened to a waist diameter of about 24μm (short axis: dX), 36μm (long axis: dY) and λ~1026μm, as shown in Fig. 2.
The obtained AFCTF was centrally inserted in a capillary tube with the length and inner diameter of 1.7 cm and 123 μm, respectively. The proposed vibration sensor is attached and fixed well in capillary by the epoxy on both sides. The process enables the sensing element to be well protected and make the sensor structure more robust, as shown in Fig. 3.

Figure 4 presents the experimental setup for sensing the vibration. Light from a tunable laser with a wavelength of 1550nm propagates into the sensor, and the output power is detected by a power meter. The electronic signals from the power meter are directly collected using an oscilloscope. The tapered region of AFCTF is bent by the vibration from the speaker, varying the output laser power. The vibration causes the output power of the sensor to oscillate at the current driving vibration frequency. The time-domain power signals are then collected and converted to frequency spectra using the fast Fourier transform. In the cross section of FCF, X and Y axes are defined as horizontal and vertical horizontal directions, respectively.
Figure 5 shows the operating principle of the proposed vibration sensor with X and Y directions. Light propagates into tapered fiber that excites high-order modes. The tapered region of the AFCTF oscillates with bending, strongly enhancing the evanescent wave of the high-order modes that leaks out. Therefore, the intensity varies periodically with amplitude that is related to the driving frequency and the driving power/amplitude of the acoustic speaker. It can be predicted that sensor vibrates along the Y direction (long axis) with thicker diameter would lower the high-order modes leaky so that SNR (signal noise ratio) of the vibration response in the Y-direction is smaller than that of the X-axis.

3. Experimental Results and Discussion

To investigate the effectiveness of the directional vibration of the proposed AFCTF, the sensor is horizontally and vertically placed near to a commercial speaker at a room temperature of 25°C, respectively. The speaker is driven by a function generator that provides sinusoidal signals with various driving amplitudes/powers and frequencies. Laser light propagates into the fiber sensor, so the variation in the output power that is caused by the acoustic vibration can be
detected by a power meter. The electronic signals are directly collected by an oscilloscope to obtain the power of the signals in the time domain and the frequency domain.

Figures 6(a)-(d) respectively plot the experimentally measured vibrations at 50 Hz, 100 Hz, 1 kHz and 5 kHz with a driving power of about 0.7 W. The obtained frequency responses with the high order harmonics and their corresponding optical responses (output voltages) from the power meter are presented. The insets show the measured time domain optical signals when under the corresponding vibration frequency, respectively. The output power that is associated with the micro-bending of the AFCTF that is related to the acoustic vibrations. It was measured using a power meter that reveals good sinusoidal waveform with an uniform amplitude. The modulated frequency of vibration is close to that of the electrical signal. Furthermore, the SNR of vibration responses in X and Y directions are obviously different to show the directional dependency. So that it can be used in the directional vibration measurement. The signal at the main frequency overcomes the harmonics, enabling the vibration to be clearly measured. Table 1 shows comparison for the SNR of the proposed sensor under the vibration at the X and Y directions, respectively. From the Table 1, it can be seen that the SNR$_X$ of X-direction is apparently higher than that of Y-direction (SNR$_Y$) with over 15 dB. The sensor has potential application for sensing direction and magnitude of the vibrations. The data in the Table 1 is also presented graphically in Fig. 7.
Fig. 6: The frequency-domain spectra of the proposed vibration sensor oscillated by a speaker of (a) 50Hz, (b) 100Hz, (c) 1kHz, and (d) 5kHz. The insets display the corresponding time-domain spectra.
Conclusion

We have developed and demonstrated a directional acoustic vibration sensor based on a AFCTF. The device has been used to measure the acoustic vibrations and to be demonstrated the sensitive responses with directional correlation. The sensor is based on micro-bending of the taper that is induced by acoustic vibrations and changes the transmission output power. The results show modulated frequency of vibration is close to that of the measured electrical signal with high SNR over 60 dB along the short axis direction vibration (X-axis). Owing to these favorable characteristics, the simple fiber sensor has potential for sensing vibrations with directional in various fields.

Table 1: Comparisons for the SNR of the proposed sensor under the vibrations of X and Y directions.

<table>
<thead>
<tr>
<th>Vibration Frequency</th>
<th>SNRx in X Direction (dB)</th>
<th>SNRy in Y Direction (dB)</th>
<th>Difference (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5kHz</td>
<td>38</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>2kHz</td>
<td>58</td>
<td>28</td>
<td>30</td>
</tr>
<tr>
<td>1kHz</td>
<td>55</td>
<td>40</td>
<td>15</td>
</tr>
<tr>
<td>600Hz</td>
<td>64</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>500Hz</td>
<td>61</td>
<td>30</td>
<td>31</td>
</tr>
<tr>
<td>400Hz</td>
<td>53</td>
<td>38</td>
<td>15</td>
</tr>
<tr>
<td>300Hz</td>
<td>55</td>
<td>43</td>
<td>12</td>
</tr>
<tr>
<td>200Hz</td>
<td>58</td>
<td>24</td>
<td>34</td>
</tr>
<tr>
<td>100Hz</td>
<td>58</td>
<td>30</td>
<td>28</td>
</tr>
<tr>
<td>50Hz</td>
<td>57</td>
<td>42</td>
<td>15</td>
</tr>
<tr>
<td>10Hz</td>
<td>58</td>
<td>39</td>
<td>19</td>
</tr>
<tr>
<td>Average</td>
<td>55</td>
<td>33</td>
<td>22</td>
</tr>
</tbody>
</table>

Fig. 7: SNR in X and Y direction of the proposed sensor under different vibration frequency.

4. Conclusion

We have developed and demonstrated a directional acoustic vibration sensor based on a AFCTF. The device has been used to measure the acoustic vibrations and to be demonstrated the sensitive responses with directional correlation. The sensor is based on micro-bending of the taper that is induced by acoustic vibrations and changes the transmission output power. The results show modulated frequency of vibration is close to that of the measured electrical signal with high SNR over 60 dB along the short axis direction vibration (X-axis). Owing to these favorable characteristics, the simple fiber sensor has potential for sensing vibrations with directional in various fields.
5. References


ICEAI-1108
A Low Cost Fiber Optic Sagnac Interferometric Perimeter Intrusion Detection System

Ping-Tzan Huang, Guan-Zuo Chen, Likarn Wang
Department of Electrical Engineering, National Tsing Hua University, Taiwan
huangpt317@gmail.com

Tai-Lang Jong
Department of Electrical Engineering, National Tsing Hua University, Taiwan
tljong@mx.nthu.edu.tw

Chi-Wen Hsieh
Department of Electrical Engineering, National Chiayi University, Taiwan

1. Background, Objectives and Goals
Fiber optic sensors are the most cost-effective solution in constructing perimeter security systems. In this paper, a fiber Sagnac interferometric perimeter intrusion detection system is developed. Intrusion detection is implemented by discriminating the frequency domain features of the Sagnac output. From experimental results, low FAR and FRR can be achieved.

2. Methods
A. Sagnac Interferometer (SI)
The detector of SI receives the interference result of the lights from two fiber paths, the clockwise loop and the counterclockwise loop, as shown in Figure 1(a). When an external disturbance occurs at some point along the optical fiber, a distortion in the optical path length of the optical fiber loop appears and a time-dependent phase shift \( (t) \) between the CW and CCW waves will be induced. When \( L_1 \neq L_2 \), it can be shown that the detector intensity \( I \) depends on the difference of the time-dependent phase shift between the CW and CCW waves:

\[
I = I_0 \left[ 1 + \cos(\theta_{ccw} - \theta_{cw}) + \theta(t-L_2) - \theta(t-L_1) \right]
\]  

(1)

where \( \theta_{cw}, \theta_{ccw} \) are the phase shifts of light in CW and CCW, and \( L_1, L_2 \) denotes the travelling times from photo-coupler to the point of disturbance along CW and CCW paths, respectively.

B. Intrusion Detection Algorithm
The SI detector output is continuously monitored with 2.5 kHz sampling rate and a pattern classification approach is adopted to detect intrusion events and non-intrusive events, as shown
in Figure 1(b). Firstly, vast SI detector output data for intrusion and non-intrusion events are collected and analyzed. We found that good detection can be achieved by examining the frequency contents of the detector outputs. Each 512-sample frame of the detector output is converted to frequency spectrum and then a frequency threshold is applied to obtain two features, namely the low frequency component \( \text{Mean}_L \) and high frequency component \( \text{Mean}_H \) for the frame. The intrusion detection is then performed based on the two features. Figure 1(c) shows detection error for different frequency thresholds. A threshold of 166 Hz would result in the best detection errors.

3. Expected Results and Conclusion

Four classifiers, namely linear discriminant (LDA), quadratic discriminant (QDA), support vector machine (SVM), and logic regression (LR) are used in the experiments for intrusion detection and the detection results are shown in Figure 1(d) to (g), respectively. A total of 10850 data frames out of intrusion events and non-intrusion events are used in these plots. The calculated decision boundary, misses (FP), false alarms (FN), and support vectors for SVM are also shown. In addition, false accept rate (FAR), false reject rate (FRR), misclassification error (ME) and relative foreground area error (RAE) for the four classifiers are summarized in Table 1. It is found that the SVM has better average error rate than others.
4. Acknowledgment

This work is supported in part by the Ministry of Science and Technology, Taiwan, under contract number: MOST 104-2221-E007-085.

Keywords: fiber optic sensor, Sagnac interferometer, signal processing, classifier
ICEAI-1033
Comparisons of Individual and Group Replacement Policies for Two Machines Series Connection System

Wen Liang Chang*
General Education of Holistic Education Center,
Cardinal Tien Junior College of Healthcare & Management, Taiwan
E-mail address: chang@ctcn.edu.tw

Mei Wei Wang
Department of Industrial Management,
National Taiwan University of Science and Technology, Taiwan
E-mail address: M10201008@mail.ntust.edu.tw

Abstract
This paper studies the comparisons of individual and group replacement policies for a series connection system with two machines. Suppose that manufacturer’s production system is a series connection system which is combined by two machines. For two machines, when machines fail within the operating time, minimal repair is performed for machines by the manufacturer. Manufacturer plans to preventive replacement for machines at a pre-specified time to maintain system normal operation. Under these maintenance policies, the maintenance cost rate models of individual and group replacement for a series connection system with two machines is derived and further, optimal preventive replacement time is obtained such that the expected total maintenance cost rate is minimized. Finally, some numerical examples are given to illustrate the influences of individual and group replacement policies to the maintenance cost rate.

Keywords: Individual replacement, Group replacement, Replacement time, Two machines, Series connection system

1. Introduction
In the production process, it is an important item whether production system is normal operation. To maintain production system normal operation, manufactures must plan to maintenance policy of production system. In general, maintenance planning can be classified into corrective maintenance and replacement. For corrective maintenance action, minimal repair is often adopted to restore failed equipment (Nakagawa & kowada (1983)). After minimal repair, the equipment is in normal operation but the failure rate function remains unchanged. Nakagawa (Nakagawa (1981)) used minimal repair to restore failed equipment back to operational status and the failure rate of the equipment remains unchanged after
performing a minimal repair. Various maintenance models involving minimal repair can be found in the literatures (Boland & Proschan (1982), Phelps (1983), Sheu (1991)).

For replacement action, two types of replacement actions: (i) Preventive Replacement (PR) and (ii) Failed Replacement (FR). PR is performed at a fixed time when the product is operational (Yeh et al. (2007)), whereas FR is performed when the product fails (Sheu (1997)). Cheng and Li (2014) studied a deteriorating repairable system with two-types of failure states and used a replacement policy $N$ based on the failure number of the system to construct average cost rate of the system. Then, an optimal replacement policy $N^*$ is obtained such that the average cost rate is minimized. Various replacement policies of the product can be found in the literatures (Qian et al. (2003), Moghaddam & Usher (2011), Zhang & Wang (2011)).

This paper investigates the effects of the individual and group replacement policies of two machines for average cost rate. The outline of this paper is described as follows. The mathematical model is derived in Section II. The optimal replacement policies are obtained in Section III. In Section IV, the effects of individual and group replacement policies are illustrated through numerical examples. Finally, some conclusions are drawn in the last section.

2. Model Formulation

Suppose that Manufacturer’s production system is combined by two machines $(M_i, i=1,2)$ using series connection method. The probability density distribution, cumulative probability density distribution, failure rate, and cumulative failure rate of the machines $M_i$ are $f_i(t)$, $F_i(t)$, $h_i(t)$ and $H_i(t)$, $i=1,2$, respectively. Manufacturer plans to perform preventive replacement for the machines at a pre-specified time to maintain system normal operation. The pre-specified individual replacement time and group replacement time for the machines $M_i$, $i=1,2$ are $T_i$, $i=1,2$ and $T_g$, respectively.

Under individual replacement policy, when the machines $M_i$, $i=1,2$ fails, minimal repair is performed with a fixed repair cost $C_{mi}$, $i=1,2$ and incurs a fixed downtime cost $C_{dmi}$, $i=1,2$, simultaneously. Since the failure of the machines is remedied by the minimal repair, the failure process of the machines $M_i$, $i=1,2$ is a non-homogeneous Poisson process with intensity function $h_i(t)$, $i=1,2$. Therefore, the expected repair cost of the machines $M_i$, $i=1,2$ within the pre-specified individual replacement time $T_i$ is $(C_{mi}+C_{dmi}+C_{dm2})H_i(T_i)$, $i=1,2$.

If the operation time of the machines $M_i$, $i=1,2$ reaches a pre-specified replacement time $T_i$, $i=1,2$, then a replacement action is performed with a fixed replacement cost $C_{ri}$, $i=1,2$ for the machines and incurs a fixed downtime cost $C_{dri}$, $i=1,2$, simultaneously. Hence, The expected replacement cost of the machines $M_i$, $i=1,2$ is $C_{ri}+C_{dri}+C_{dri2}$, $i=1,2$. Hence, within individual replacement time $T_i$, $i=1,2$, the expected total cost rate is
\[ E(C(T_1, T_2)) = \sum_{i=1}^{2} \frac{(C_{ni} + C_{dni} + C_{dmi}) H_i(T_i) + C_{ri} + C_{dri} + C_{dr}}{T_i}. \] (1)

Under group replacement policy, the expected repair cost is similar to the expected repair cost of individual replacement policy. Within group replacement time \( T_g \), the expected repair cost of the machines \( M_i, i=1,2 \) is \((C_{mi}+C_{dni}+C_{dmi})H(T_g), i=1,2\). When the operation time of machines reaches a pre-specified replacement time \( T_g \), all machines are replaced and incurs a fixed replacement cost \( C_{r1}+C_{r2}+C_{dri}+C_{dr} \). Therefore, within group replacement time \( T_g \), the expected total cost rate is

\[ E(C(T_g)) = \sum_{i=1}^{2} \frac{(C_{ni} + C_{dni} + C_{dmi}) H_i(T_g) + C_{ri} + C_{dri} + C_{dr}}{T_g}. \] (2)

The objective of this paper is to find the optimal replacement time \( T_i, i=1,2 \) and \( T_g \) such that the expected total cost rate \( E(C(T_1, T_2)) \) and \( E(C(T_g)) \) in Eqs. (1) and (2) is minimized, respectively.

### 3. Optimal Replacement Policy

Based on the objective functions (1) and (2), the optimal replacement policies of individual and group replacement are derived as follows.

#### 3.1 Individual Replacement

To investigate the replacement time \( T_i, i=1,2 \), we take the first partial derivative of Eq. (1) with respect to \( T_i \). The result is

\[ \frac{\partial E[C(T_1, T_2)]}{\partial T_i} = \frac{K_i(T_i) - (C_{ri} + C_{dri} + C_{dr})}{T_i^2}, i=1,2 \] (3)

where \( K_i(T_i) = (C_{mi}+C_{dni}+C_{dmi})[T_i h_i(T_i) - H_i(T_i)], i=1,2 \).

Observing \( K_i(T_i), i=1,2 \), the following property 1 holds.

**Property 1.** If \( h_i'(t) > 0, i=1,2, \forall t > 0 \), then we have \( K_i(T_i) \) is a strictly increasing with \( T_i \), \( \lim_{T_i \to 0} K_i(T_i) = 0 \), and \( \lim_{T_i \to \infty} K_i(T_i) > 0, i=1,2 \).

**Proof.** If \( h_i'(t) > 0, i=1,2, \forall t > 0 \), then we have \( dK_i(T_i)/dT_i > 0 \). This implies that \( K_i(T_i) \) is a strictly increasing function of \( T_i \) and \( \lim_{T_i \to 0} K_i(T_i) = 0, i=1,2 \). Since \( K_i(T_i) \) is a strictly increasing
\[ \frac{\partial E[C(T_i,T_j)]}{\partial T_i} = \frac{K_i(T_j) - (C_{ni} + C_{dr1} + C_{dr2})}{T_i^2} \cdot i = 1,2 \]  

function, then \( \lim_{i \to \infty} K_i(T) > 0, i=1,2 \). ■

Observing Eq. (3), the following theorem holds.

**Theorem 1.** When \( h_i'(t) > 0, i=1,2, \forall t > 0 \), the following results hold.

(a) If \( K_i(\infty) < C_{ri} + C_{dr1} + C_{dr2} \), then optimal \( T_i^* = \infty, i=1,2 \).

(b) If \( K_i(\infty) \geq C_{ri} + C_{dr1} + C_{dr2} \), then there exists a unique solution \( T_i^* \in [0, \infty) \) such that \( K_i(T_i^*) - (C_{ri} + C_{dr1} + C_{dr2}) = 0, i=1,2 \).

**Proof.** When \( h_i'(t) > 0, i=1,2, \forall t > 0 \), \( h_i(t) \) is a strictly increasing function and the following results hold.

(a) If \( K_i(\infty) < C_{ri} + C_{dr1} + C_{dr2} \), then \( \frac{\partial E[C(T_1,T_2)]}{\partial T_i} < 0, i=1,2 \). This implies that \( E[C(T_1,T_2)] \) is a decreasing function of \( T_i, i=1,2 \). Therefore, the optimal \( T_i^* = \infty, i=1,2 \).

(b) If \( K_i(\infty) \geq C_{ri} + C_{dr1} + C_{dr2} \), then \( \frac{\partial E[C(T_1,T_2)]}{\partial T_i} \geq 0, i=1,2 \). From the results of property 1, \( K_i(T) \) is a strictly increasing function. Substituting \( T_i=0 \) into \( K_i(T) \), \( K_i(0)=0 < C_{ri} + C_{dr1} + C_{dr2}, i=1,2 \) is obtained. Therefore, \( \frac{\partial E[C(T_1,T_2)]}{\partial T_i} \) changes its sign exactly once from negative to positive in the interval \([0, \infty)\) and there exists a unique \( T_i^* \in [0, \infty) \) such that

Since \( K_i(T_i^*) = (C_{ni} + C_{dni} + C_{dmi}) \left[ T_i^* h_i'(T_i^*) - H_i(T_i^*) \right], i=1,2 \), we have

\( (C_{mi} + C_{dni} + C_{dmi}) H_i(T_i^*) = (C_{mi} + C_{dni} + C_{dmi}) T_i^* h_i'(T_i^*) - (C_{ri} + C_{dr1} + C_{dr2}), i=1,2 \).

Substituting \( T_i^* \) and \( (C_{mi} + C_{dni} + C_{dmi}) H_i(T_i^*) \), \( i=1,2 \) into Eq. (1), the expected total cost rate can be rewritten as

\[ E[C(T_1,T_2)] = \sum_{i=1}^{2} (C_{ni} + C_{dni} + C_{dmi}) h_i(T_i^*). \]  

(4)

### 3.2 Group Replacement

Based on Eq. (2), taking the first derivative of Eq. (2) with respect to \( T_g \), we have

\[ \frac{dE[C(T_g)]}{dT_g} = \frac{K(T_g) - (C_{r1} + C_{r2} + C_{dr1} + C_{dr2})}{T_g^2} \]  

(5)

where \( K(T_g) = \sum_{i=1}^{2} (C_{mi} + C_{dni} + C_{dmi}) [T_g h_i(T_g) - H_i(T_g)] \).
Observing $K(T_\varepsilon)$, the following property 3 holds.

**Property 2.** If $h_i'(t) > 0, i = 1, 2, \forall t > 0$, then we have $K(T_\varepsilon)$ is a strictly increasing.

$$\lim_{t \to 0} K(T_\varepsilon) = 0, \quad \text{and} \quad \lim_{t \to \infty} K(T_\varepsilon) > 0.$$ 

**Proof.** If $h_i'(t) > 0, i = 1, 2, \forall t > 0$, then we have $dK(T_\varepsilon)/dT_\varepsilon > 0$. This implies that $K(T_\varepsilon)$ is a strictly increasing function of $T_\varepsilon$ and $\lim_{t \to \infty} K(T_\varepsilon) = 0$. Since $K(T_\varepsilon)$ is a strictly increasing function, then $\lim_{t \to \infty} K(T_\varepsilon) > 0$. 

Observing Eq. (5), the following theorem 3 holds.

**Theorem 2.** When $h_i'(t) > 0, i = 1, 2, \forall t > 0$, the following results hold.

(a) If $K(\infty) < C_{r1} + C_{r2} + C_{dr1} + C_{dr2}$ then optimal $T_\varepsilon^* = \infty$.

(b) If $K(\infty) \geq C_{r1} + C_{r2} + C_{dr1} + C_{dr2}$, then there exists a unique $T_\varepsilon^* \in [0, \infty)$ such that $K(T_\varepsilon^*) - (C_{r1} + C_{r2} + C_{dr1} + C_{dr2}) = 0$.

**Proof.** When $h_i'(t) > 0, i = 1, 2, \forall t > 0$ is a strictly increasing function and the following results hold.

(a) If $K(\infty) < C_{r1} + C_{r2} + C_{dr1} + C_{dr2}$, then $dE[C(T_\varepsilon)]/dT_\varepsilon < 0$ in Equation (5), that is, $E[C(T_\varepsilon)]$ is a decreasing function of $T_\varepsilon$. Therefore, the optimal $T_\varepsilon^* = \infty$.

(b) If $K(\infty) \geq C_{r1} + C_{r2} + C_{dr1} + C_{dr2}$, then $dE[C(T_\varepsilon)]/dT_\varepsilon \geq 0$ in Equation (5). From the results of property 2, $K(T_\varepsilon)$ is a strictly increasing function. Substituting $T_\varepsilon = 0$ into $K(T_\varepsilon)$, $K(0) = 0 < C_{r1} + C_{r2} + C_{dr1} + C_{dr2}$ is obtained. Therefore, $dE[C(T_\varepsilon)]/dT_\varepsilon$ changes its sign exactly once from negative to positive in the interval $[0, \infty)$ and there exists a unique solution $T_\varepsilon^*$ such that $dE[C(T_\varepsilon)]/dT_\varepsilon |_{T_\varepsilon^*} = 0$, that is, $K(T_\varepsilon^*) - (C_{r1} + C_{r2} + C_{dr1} + C_{dr2}) = 0$. 

Since $K(T_\varepsilon^*) = \sum_{i=1}^{2} (C_{mi} + C_{m1i} + C_{m2i}) [T_\varepsilon^* h_i'(T_\varepsilon^*) - H_i(T_\varepsilon^*)]$, we have

$$\sum_{i=1}^{2} (C_{mi} + C_{m1i} + C_{m2i}) H_i(T_\varepsilon^*) = \sum_{i=1}^{2} (C_{mi} + C_{m1i} + C_{m2i}) T_\varepsilon^* h_i'(T_\varepsilon^*) - (C_{r1} + C_{r2} + C_{dr1} + C_{dr2})$$
Suppose that the lifetime distribution of Machine \( M_i, i=1,2 \) follows a two-parameter Weibull distribution. According to definition of a failure rate function, the failure rate function of the Weibull distribution is

\[
\lambda(t) = \frac{\alpha_i}{\beta_i t^{\beta_i - 1}},
\]

where \( \alpha_i > 0 \) and \( \beta_i > 1, i=1,2 \) and then the expected life time is

\[
u_i = \frac{1}{\alpha_i} \Gamma\left(1+\frac{1}{\beta_i}\right), i=1,2.
\]

The following parameter values are considered.

\[
\begin{align*}
\alpha_1 &= 0.5, 0.15, \\
\beta_1 &= 1.4, 2, 2.5, \\
\alpha_2 &= 0.35, \\
\beta_2 &= 1.6, 2, 2.5, 3, \\
C_{dm1} &= C_{dm2} = C_{dr1} = C_{dr2} = 100, \\
C_{m1} &= 300, \\
C_{m2} &= 100, \\
C_{r1} &= 700, \\
C_{r2} &= 800.
\end{align*}
\]

Tables 1 and 2 summarize the optimal replacement time and expected total cost rate under \( u_1 < u_2 \) and \( u_1 > u_2 \). From Tables 1 and 2, some results are obtained as follows.

1) Under the expected life time \( u_1 < u_2 \), when \( \beta_2 > 2 \), the expected total cost rate of group replacement is lower than individual replacement.
2) When the expected life time \( u_1 > u_2 \), when \( \beta_2 > 2 \), the expected total cost rate of individual replacement is lower than group replacement.
This paper studies the comparisons of individual and group replacement policies for a series connection system with two machines. From the results of numerical examples, we have some conclusions as follows: 1) When the failure rate of machine $M_2$ is a strictly increasing function, the expected total cost rate of group replacement is lower than individual replacement. 2) Under the expected life time of two machines is different, when the failure rate of machine $M_2$
is a strictly increasing function, the expected total rate of individual replacement is lower than group replacement. Furthermore, some generalizations, such as classification replacement, multiple machines, renewing free-replacement warranty, non-renewing free-replacement warranty are extended issues for future study in this area.

6. References
ICEAI-1044

Development of Free-Leg Hexapod Machining Tool

Sunghee Choi
Precision Control Research Center, Electric Propulsion Research Division of Korea
Electrotechnology Research Institute, Republic of Korea
dhmgbds@keri.re.kr

Chang Nho Cho
Precision Control Research Center, Electric Propulsion Research Division of Korea
Electrotechnology Research Institute, Republic of Korea
chcho@keri.re.kr

Hong-ju Kim*
Precision Control Research Center, Electric Propulsion Research Division of Korea
Electrotechnology Research Institute, Republic of Korea
hjkim@keri.re.kr

Abstract

Conventional CNC machines are installed in a factory or workshop to manufacture various products. However, if installed machined parts need a modification or repair, the part must be disassembled and transferred back to the factory. Thus, such a process is often inefficient and expensive. In order to cope with this issue, in this study, a new type of machining platform is proposed. The new machining platform is a combination of a free leg hexapod (freeHEX) robot and spindle. The proposed freeMCT (free-leg hexapod machining tool) can perform 3 DOF position and 3 DOF orientation control based on the given NC code. This paper will introduce the simplified modeling for machining and the developed freeMCT. Also, the future research directions of the freeMCT are discussed.

Keywords: free-leg, hexapod, machining tool, freeMCT,

1. Introduction

Recently, with the expiration of ABB’s patent on delta robots, engineers can now design a machining center with a parallel structure to improve the stiffness and speed of the machine. Also, by adopting parallel structures, the requirements on actuator capacity can be effectively reduced. These features make a parallel platform a good candidate for a machining platform, as a machining platform with high accuracy, speed, and stiffness is desired. In this study, we propose a special machining tool which has a parallel structure and can move along the workspace.
Its parallel links and joints act like a leg, which allows the machining tool to walk. A spindle is placed at the center of the body, so that the freeMCT can perform machining according to the given g-code. As can be seen from Fig. 1, the legs of freeMCT have 3 R structure, which can be simplified as R-P-R. Thus, the developed machining tool can be controlled as a Stewart Platform. (R.L.Norton. 2004)

2. Modeling of Stewart Platforms for Machining

The Stewart Platform is a manipulator consists of six linear actuators. The linear actuators are connected to the manipulator via universal and spherical joints, so that the whole manipulator forms a closed kinematic chain. (D. Jakobovic and L. Jelenkovic, 2002)

![Fig.1 FreeMCT perform as a planner 2-RPR parallel mechanism](image)

This unique structure provides the Stewart Platform six DOF (degrees of freedom), three in position and three in orientation. Let $l_i$, $a_i=(a_{i1},a_{i2},a_{i3})^T$, $b_i=(b_{i1},b_{i2},b_{i3})^T$, $i=1,...,6$, be the length of a prismatic leg, position of the center of the universal $(A_i)$ and spherical joint $(B_i)$, respectively (Fig. 2). The position of the platform can be described by a position vector $p=(x_p,y_p,z_p)^T$. As for the orientation, either a rotation matrix, $R$, or Euler angles $(\phi_p, \theta_p, \psi_p)$ with respect to the base frame, can be used. Then, the platform attachment $b_i$ can be defined in the base frame as (P. Cirillo, G. De Maria, C. Natale. 2015)

$$b_i = p + R\tilde{b}_i (b_{i1},b_{i2},b_{i3})^T$$  \hspace{1cm} (1)

In order to control the Stewart Platform, its inverse kinematics and Jacobian are required. The static problem and inverse dynamics problem of the Stewart Platform will be discussed in the next section.
2.1 Inverse Kinematics

For a Stewart Platform, the goal of the inverse kinematics problem is to solve for the leg length $l_i$, given the desired position $P$ and orientation $(\varphi_p, \theta_p, \psi_p)$. (D. Jakobovic and L. Jelenkovic 2002) The solution for the inverse kinematics problem is given in eq. (2). Note that $b_i$ can be calculated using eq. (1).

$$l_i - \|b_i - ai\|$$  \hspace{1cm} (2)

2.2 Statics

Let $X = [x_p, y_p, z_p, \varphi_p, \theta_p, \psi_p]^T$ and $q = [l_1, l_2, l_3, l_4, l_5, l_6]^T$ denote the six Cartesian coordinate and six leg lengths of a Stewart Platform, respectively. The leg length $l_i$ can be computed using:

$$l_i = \sqrt{x_p - a_{i1} + b_{i2} + b_{i3}(c_{\varphi_p}^2 + c_{\theta_p}^2) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$

$$l_i = \sqrt{y_p - a_{i1} + b_{i2}(c_{\varphi_p}^2 + c_{\theta_p}^2) + b_{i3}(c_{\varphi_p}c_{\theta_p} - c_{\varphi_p}c_{\psi_p} - c_{\psi_p}c_{\varphi_p}) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$

$$l_i = \sqrt{z_p - a_{i1} + b_{i2}(c_{\varphi_p}c_{\theta_p} + c_{\varphi_p}c_{\psi_p}) + b_{i3}(c_{\varphi_p}c_{\theta_p} - c_{\varphi_p}c_{\psi_p} - c_{\varphi_p}c_{\psi_p}) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$

$$l_i = \sqrt{\varphi_p - a_{i1} + b_{i2}(c_{\varphi_p}^2 + c_{\theta_p}^2) + b_{i3}(c_{\varphi_p}c_{\theta_p} - c_{\varphi_p}c_{\psi_p} - c_{\psi_p}c_{\varphi_p}) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$

$$l_i = \sqrt{\theta_p - a_{i1} + b_{i2}(c_{\varphi_p}c_{\theta_p} + c_{\varphi_p}c_{\psi_p}) + b_{i3}(c_{\varphi_p}c_{\theta_p} - c_{\varphi_p}c_{\psi_p} - c_{\varphi_p}c_{\psi_p}) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$

$$l_i = \sqrt{\psi_p - a_{i1} + b_{i2}(c_{\varphi_p}c_{\theta_p} + c_{\varphi_p}c_{\psi_p}) + b_{i3}(c_{\varphi_p}c_{\theta_p} - c_{\varphi_p}c_{\psi_p} - c_{\varphi_p}c_{\psi_p}) - b_{i4}c_{\varphi_p}c_{\theta_p} - b_{i5}c_{\varphi_p}c_{\psi_p} - b_{i6}c_{\varphi_p}c_{\psi_p}}$$
where \(x(t)\) is the pose of the Stewart Platform with respect to the base frame, \(b\) is a constant greater than 1, and \(s_\alpha\) and \(c_\alpha\) are \(\sin(\alpha(t))\) and \(\cos(\alpha(t))\), respectively. Note that the time dependence is omitted in eq. (3). On the other hand, the analytical Jacobian of a Stewart Platform is given by (S. Satya, P. M. Ferreira and M. W. Spong, 1995)

\[
J_A(q) = \frac{\partial \mathbf{q}(x)}{\partial \mathbf{x}}
\]

(4)

Using the inverse kinematics solution, one can derive the inverse differential mapping between the workspace velocity \(\dot{X} = [\dot{x}_p, \dot{y}_p, \dot{z}_p, \dot{\phi}_p, \dot{\psi}_p, \dot{\theta}_p]^T\) and the leg velocity \(\dot{X} = [\dot{v}_p, \dot{y}_p, \dot{z}_p, \dot{\phi}_p, \dot{\psi}_p, \dot{\theta}_p]^T\) of a Stewart Platform.

\[
\dot{q} = J_A(X)\dot{X}
\]

(5)

where \(J_A\) is the analytical Jacobian. Note that the subscript \(A\) is used to distinguish it from the geometric Jacobian \(J\), which relates the joint velocity to the end effector velocity \(V = [\dot{v}_e, \dot{\omega}_e]^T\), where \(\dot{v}_e\) is the linear velocity and \(\dot{\omega}_e\) is the angular velocity. The inverse kinematics mapping for the geometric Jacobian is given by:

\[
\dot{q} = J(X)V
\]

(6)

### 3. Modeling of Stewart Platforms for machining

The arachnid leg type is used to lower the center of mass of the freeMCT and thus increase its stability during a machining process. Figure 3 depicts the 3d model of the freeMCT. It should be noted that its circular legs orientation structure equally distributes the weight of the spindle to each legs. (F. Tedeschi, G. Carbone, 2014) The general specifications of the freeMCT are listed below:

- Maximum workspace (80mm (radius) x 60mm (high)) and weight (10.5kg)
- The 3-axis of CNC movements ensure the capability. Movements are controllable 6 Axis (x,y,z, roll, pitch, yaw).
- Maximum feed speed 20mm/s and spindle speed 12,000 rpm
- Step size 130 mm ~ 350 mm

The overall system of the developed freeMCT is shown in Fig. 3 (b). In order to perform a machining task, the freeMCT must be able to interpret g-code and control the motion of the platform. Thus, a PC-based control system is used, and its specifications are listed below:
The freeMCT is controlled via RS-485 communication at the control period of 100 Hz. The controller also provides a GUI (Graphical User Interface) so that the operator can easily control the robot.

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>Intel i5 M480 2.67</td>
</tr>
<tr>
<td>OS</td>
<td>Windows7 64bit</td>
</tr>
<tr>
<td>RAM, Storage</td>
<td>4 GB, SSD 120Gbyte</td>
</tr>
<tr>
<td>IO board</td>
<td>Arduino uno</td>
</tr>
</tbody>
</table>

Table 1: Description of the FreeMCT Controller

The freeMCT is controlled via RS-485 communication at the control period of 100 Hz. The controller also provides a GUI (Graphical User Interface) so that the operator can easily control the robot.

3.1 Control Procedure

Figure 5 shows the overall control procedure of the freeMCT. The one of the biggest advantage of the freeMCT over conventional machining platform is that it can walk to the desired machining location. Thus, first, the freeMCT is given the NC code and desired location. Then, assuming the freeMCT can estimate its present position using appropriate sensors, the freeMCT moves to the desired location. It generates the motion profile in the workspace and moves until it reaches the desired location. Once it is at the desired location, the freeMCT interprets NC code and perform machining. (S.Choi, C.N. Cho, H.J.Kim 2015)
4. Conclusion

In this study, the freeMCT, a machining platform with a parallel structure is proposed. Its Stewart Platform-like structure ensures high accuracy and stiffness. Also, as the freeMCT has 6 legs, it can freely walk over the workspace. Thus, the developed platform provides large workspace and higher flexibility. The prototype of the freeMCT has been developed and control algorithms were derived based on the Stewart Platform. We expect that the developed freeMCT can be used for many environments where conventional machining tools are not applicable. For the future study, sensors such as a stereo camera or laser scanner will be added to the system, so that the freeMCT can reach the desired location while avoiding obstacles.

5. Acknowledgments

This research was supported by Korea Electrotechnology Research Institute(KERI) Primary research program through the National Research Council of Science & Technology(NST) funded by the Ministry of Science, ICT and Future Planning(MSIP) (No. 16-12-N0101-51)

6. References

P. Cirillo, G. De Maria, C. Natale. (2015). Customization of low-cost hexapod robots based on optimal design through inverse dynamics computation. MMAR.1110-1115. doi: 10.1109/MMAR.2015.7284034


ICEAI-1099
Study on the AM60Bs Mechanical Properties for the MgO-CNT Addition

Min Seok Moon, Myeong Han Yoo, Je Ha Oh, Joon Hyuk Song
Convergence Process Division, Korea Institute of Carbon Convergence Technology,
Republic of Korea
E-mail address: msmoon@kctech.re.kr

Shin Jae Kang
Dept. of Mechanical Design, Chonbuk National University, Republic of Korea

Sung Mo Yang
Dept. of Mechanical System Engineering, Chonbuk National University, Republic of Korea

Kee Do Woo
Dept. of Advanced Materials Engineering, Chonbuk National University, Republic of Korea

1. Background/ Objectives and Goals
Magnesium alloy is gradually increasing its use of lightweight materials in the motor vehicle industry during the a few years ago. The Magnesium alloy has an excellent tenacity on the non-ferrous materials. The AM60B alloy is using for the replacement of the conventional steel parts or Aluminum parts recently. Normally, magnesium alloy is applying to the production process by high pressure die-casting. The Magnesium alloy's forming technology has applied to the interior and exterior parts for the automotive components through actively studying. Commonly, the CNT dispersion processing techniques are developed to purpose to the excellent mechanical properties for the polymer composites materials. For a metal material of a research field, the CNT materials are addition method developing to utilizing research for making the metallic alloys, recently. However, the CNT material has due to aggregation properties between CNT itself, and its dispersive method is developing now by a mechanical and electrical process.

In this paper, the casting process uses to the alloying method between the CNT and AM60B alloy by mechanical process.

2. Methods
The MgO-CNT material has fabricated from the CNT grown up on the MgO matrix. Also, MgO-CNT has added into the molten AM60B alloy during the melting process by a mechanical method. The totally adding the MgO-CNT quantity is 2.0wt% of total molten weight.
The melting process has adopted to the electronic melting furnace. The AM60B’s oxidation protecting process has spread SF6 on the furnace during the melting process. The AM60B pouring temperature has set on 670°C for a pouring into the metallic cast mold through gravity casting process. The metallic cast mold was preheating by 200°C.

The cast specimen was analyzing the composite's chemical composition of the CNT quantity by EDS techniques. The mechanical properties were measuring by the ASTM E8M specification through mechanical machining. During the tensile strength measuring process, the cross head speed was moving to the 2mm per minutes. The hardness was measuring the Micro Vickers hardness through indentation force 0.2kgf.

The fracture surface of the tensile testing specimen has understood the mechanical properties and micro structure's relationship through by SEM.

3. Expected Results/ Conclusion/ Contribution
The MgO-CNT added AM60B specimen has displayed to high carbon composition as 1.62wt% when it is inserting to 2.0wt% MgO-CNT into the molten AM60B. The carbon element has considered to the additive MgO-CNT materials by an indirect method.

In the tensile strength that the AM60B specimen has 121.2MPa’s UTS value, and MgO-CNT added AM60B specimen has 137.1MPa’s UTS value. It is MgO-CNT additive sample has a high strength effect by CNT addition as 13% UTS value increasing.

In the hardness result that the AM60B specimen has 33.43Hv value, and MgO-CNT added AM60B specimen has 39.63Hv value. It is MgO-CNT additive sample has 18% hardness value increasing similar with tensile test results. Therefore, the additive MgO-CNT on the AM60B’s specimen has a real increasing tensile and hardness test results by this experiment process. In this experiment, the CNT material has regarded to dispersive on the AM60B alloy during melting process.

In the microstructure of fracture side on the tensile test by SEM that the MgO-CNT added AM60B alloy’s specimen fracture surface had much dimple structures better than general AM60B alloy. Thus, This phenomenon is following a stable connection between matrix and CNT particles with high deformation mechanism by dispersive CNT materials on the MgO-CNT added AM60B alloy.

Keywords: Magnesium alloy(AM60B), MgO-CNT, Gravity casting, Mechanical properties, Lightweight materials composites
ICEAI-1102
Development of High-Pressure Diecasting Process for Vehicle Structure with Magnesium Alloy

Joon Hyuk Song, Kyung-Jae Kim, Myounghan Yoo, Min Seok Moon,
Youngsoo Park, Jeha Oh
Korea Institute of Carbon Convergence Technology, Republic of Korea
songjh@kctech.re.kr

Shinjae Kang
Dept. of Mechanical Design, Chonbuk National University, Republic of Korea

Sung Mo Yang
Dept. of Mechanical System Engineering, Chonbuk National University, Republic of Korea

1. Background/ Objectives and Goals
For light weight vehicle, advanced automobile companies apply the nonferrous metals diecasting process instated of the steel press and welding. Especially, Aluminum and Magnesium is being applied to structural parts with virtue of high specific strength for light weight.

High pressure diecasting process has been applied to structural part of vehicle with advantages as high productivity of diecasting and high quality of squeeze casting.

In this paper, Mg cowl cross member of car was developed substitute for steel with 30% light weight. Mg cowl cross member is just only one piece part instead of steel cowl cross member with mechanical joining and welding about 70 subparts. Optimum design and manufacturing process were researched for high-pressure magnesium diecasting process.

2. High-Pressure Diecasting Process
Locking force of diecasting machine is 32000kN. Component of a tie bar force were calculated for the area of projection plane 362,296 mm² under safety 20%. Max. diecasting pressure is 750MPa. Because if diecasting pressure is over than 800MPa, demanded locking force is 34084kN, this is over the value 32000kN of machine.

Under this condition, Solidification and filling conditions of high–pressure diecasting were simulated with software ‘Anycasting’. From the simulation, conditions were settled as material AM60B, filling rate 40%, diecasting pressure 750MPa, and high speed of plunger 3.5m/s. Mg cowl cross member was produced with high-pressure diecasting process.
Mechanical properties were measured with KS B 0802. Specimens were cut off from 12 sections on the cowl cross member. Properties are satisfied the target values; tensile strength 247MPa, yield strength 140 MPa, and percentage of elongation 7.0%.

3. Expected Results and Conclusions
Developed Mg cowl cross member is just only one piece part instead of steel cowl cross member with mechanical joining and welding about 70 subparts. Conclusions are as follows; Mg cowl cross member of car was developed with 30% light weight by high-pressure diecasting substitute for steel press process.

Optimum process were settled as material AM60B, filling rate 40%, diecasting pressure 750MPa, and high speed of plunger 3.5m/s

Mechanical properties of Mg cowl cross member were satisfied the target values. Finally, from the crash test(IHIS 64kph 40% OFFSET, NCAP 56 kph), we got the ‘GOOD’ and ‘5 stars(★)’.

Keywords: Lightweight Vehicle, Mg cowl cross member, High-Pressure Diecasting Process, Unification Design, IIHS 64kph 40% OFFSET, NCAP 56 kph
ICEAI-1142
Study on a Micro Multilevel Aspheric Fresnel Lens Array Fabrication

Shun-Tong Chen, Po-Tsung Lin
Department of Mechatronic Technology, National Taiwan Normal University
E-mail: chenst@ntnu.edu.tw

Abstract
This study presents a novel, economical and efficient fabrication technique for precisely generating the micro mould of multilevel aspheric Fresnel lens array to produce the micro lens array made of PMMA. A high-speed, -precision misplaced machine tool design in which the workpiece is clamped on the high-speed spindle on the Z-axis while the diamond tool is located on the working tank on the XY-axis is first designed and proposed. The optical path analysis in the single focus multilevel micro aspheric Fresnel lens is conducted and verified. The micro rod-shaped workpiece of Φ 1.0 mm diameter made of stavax is driven at 60,000 rpm so that the diamond tool performs a cross machining from the end-face of the workpiece according to the CNC path of multilevel micro aspheric Fresnel lens. An extensive quantitative and qualitative examination of the multilevel aspheric Fresnel lens is undertaken. The misplaced approach is evaluated and discussed with regard to the surface roughness of the Fresnel lens, the dimensional and geometrical accuracy at the tip of the microstructure and the tool life expectancy.

Keywords: misplaced approach, micro multilevel aspheric Fresnel lens array
ICEAI-1143
Development of a Novel Roll-to-Roll Imprinting System for Making Nanoscale Silver Wire Array

Shun-Tong Chen
Department of Mechatronic Engineering, National Taiwan Normal University, Taiwan
E-mail address: chenst@ntnu.edu.tw

Chien-Ta Huang
Department of Mechatronic Engineering, National Taiwan Normal University, Taiwan
E-mail address: alvin322592@gmail.com

This paper presents a development of a novel roll-to-roll imprinting system for imprinting the nanoscale silver wire array. A hybrid in-situ roll-to-roll imprinting system that provides high-precision machining for making nano-rollteeth structure on the roller is first developed. The imprinting system comprises the nano-rollteeth turning system, the multi-resistance-capacitance tool sharpening system, the conductive silver glue supply system and the in-situ roll-to-roll mechanism to in-situ imprinting the conductive silver wire array. By applying the designed turning system, the roller with nano-rollteeth structure array can be precisely machined by using the nano-polycrystalline composite diamond (nano-PCD) cutting tool. The finished roller need not be unloaded and repositioned until all the planned tasks are completed. The conductive silver glue is supplied onto the surface of the roller to imprint the nanoscale silver wire array to the transparent film. The strategy creates the roller with high co-axial accuracy. Correspondingly, the imprinted nanoscale silver wire array can be kept in the line breadth with highly consistent. The roller can be in-situ re-turned after dulling. Besides which, the nano-PCD cutting tool can also be in-situ sharpened by using the multi-resistance-capacitance discharge system. Due to the roll-to-roll imprinting and tool sharpening are designed for in-situ operation, the finished nanoscale silver wire array with 500 nm in line breadth and pitch can be realized. It is expected that the hybrid process will contribute significantly to the field of high-precision industry.

Keywords: nanoscale silver wire array, hybrid in-situ roll-to-roll imprinting system
Abstract

The study presents an approach for producing the high-precision critical implement – micro diamond probe with a tip-radius of 1.0µm, which is widely employed to high accuracy surface roughness measurement. To realize the high quality machining for the diamond probe, a laboratory-designed high-precision CNC grinding machine with gantry framework in which a pair of dual-spindle is designed and proposed to dress the diamond wheel for grinding the workpiece (diamond probe) is first developed in this study. The FEA (Finite Element Analysis) method is conducted for the deformation analysis of the main structural bodies. To avoid any rupture on the tip of diamond probe, caused by grinding clash between diamond wheel and diamond probe, a magnetic mechanism with elasticity is designed. The obtained deformation is within 1.0 µm, which is an acceptable level for the process of producing diamond probe. A ‘tangential type micro lapping’, by which the diamond is ground reciprocally in a nano-scale depth on the peripheral surface of diamond wheel, is employed for precisely forming the tip-radius of the diamond. Experimental results demonstrated that the diamond probe with a tip-radius of 1.0µm can be achieved via mechanical wear when the machining conditions are set at 8 mm/min feed-rate, 4,050 m/min relative velocity of the wheel and the workpiece, respectively. In measuring of surface roughness, which compared with commercial probe, the specification in JIS 2001 can be complied with the value in measured error.

Keywords: diamond probe, tangential type micro lapping, surface roughness
ICEAI-1047
Wave Interaction with a Uniform Porous Cosine-Type Cylindrical Structure

Ching-Yun Yueh
Department of Harbor and River Engineering,
National Taiwan Ocean University, Taiwan, R.O.C.
E-mail address: yuehcy@mail.ntou.edu.tw

Shih-Hsuan Chuang
Wayten Technology Co., Ltd, Taiwan (R.O.C)
E-mail address: s.h.overlay.chuang@gmail.com

Chih-Ting Chang
Department of Harbor and River Engineering,
National Taiwan Ocean University, Taiwan, R.O.C.
E-mail address: ljes40100@yahoo.com.tw

Abstract
1. Background/ Objectives and Goals
Porous structures are often constructed to reduce the wave impact force and wave run-up on coastal and offshore structures. They can also decrease the free surface fluctuation in harbor more effectively than an impermeable structure. In this study, wave interaction with a porous cosine-type cylindrical structure is investigated. The cylindrical structure is assumed to have uniform, bottom-mounted, surface-piercing and porous whose diameter exhibits a cosine-type variation and considered to be thin in thickness.

2. Methods
The fluid flow passing through the porous cosine-type cylinder is assumed to obey Darcy’s law for a homogeneous porous medium. The porous flow velocity is linearly proportional to the pressure difference between the two sides of the porous cylinder. Under the assumptions of potential flow and linear wave theory, a numerical solution has been obtained by a dual boundary element method (DBEM). There is little published material investigating the behavior wave interaction with a porous cosine-type cylindrical structure. The conventional integral equation was combined with the hypersingular integral equation, i.e., dual integral equation. In this study, by introducing the hypersingular boundary integral equation, dual BEM overcomes ill-posed problem without subdomains and therefore requires less computer memory. The dual BEM has been proven successfully when the thin structure has the form of a semi-infinite plane of finite depth. The accuracy and validity of this method have been compared to the solutions obtained by MacCamy and Fuchs (1954), Williams and Li (2000),
Mansour (2002) for dimensionless wave force, relative wave run-up and diffraction coefficient, and excellent agreement have been observed.

3. Expected Results/ Conclusion/ Contribution

The definition sketch for the cylindrical structure is shown in Fig. 1. The radial perturbation of the surface of the cylinder is given as a cosine function of two parameters, , the perturbation amplitude, and, , a positive integer representing the frequency of the perturbations. Hence, the geometrical surface of the cylindrical structure can be represented in cylindrical coordinates by the equation . The cylindrical structure of different geometrical cross section (N), different amplitude of perturbation ( ), different angle of incident wave ( ) and different porous effect parameter (G) are considered.

Using the developed computer programs, the performance of a uniform, porous cosine-type cylindrical structure are investigated and compared. The total net hydrodynamic force, wave run-up and wave diffraction on porous cosine-type cylinder are determined numerically. The numerical results show that, with the existence of the porous cosine-type cylinder, the maximum dimensionless wave force acting on the cylinder is reduced if compared to the force exerted on the impermeable cylinder. It has been found that the porous effect parameter of the cylinder may results in a significant reduction in both the hydrodynamic force and wave run-up.

The idea of dual boundary integral equations, in which a combination of the standard boundary integral equation and its derivation can be used to provide independent equations to overcome the problem of degeneracy. For coincident source points on the thin plate boundaries, the respective boundary integral equations are distinct, when the OBIE is applied to the source points on one of the thin plate boundaries and the HnDBIE is applied to the source point on the other. It is hoped that the numerical presented and the results of the parametric study will be useful in the design of coastal and harbor engineering. They should be useful in selecting a suitable cosine-type cylindrical structure for a particular application.
Keywords: Porous cosine-type cylinder, Diffraction, Run-up, Hydrodynamic force

Fig. 1 Definition sketch for the cosine-type cylindrical structure.

Keywords: Porous cosine-type cylinder, Diffraction, Run-up, Hydrodynamic force
Eccentrically Loading on Strength Analysis of the Fillet Weld Groups

Wei T, Hsu*
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: wthsu@cyut.edu.tw

Zhe L. Zhang
Dep. Of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: clark10045@gmail.com

Abstract
The welded joints Mechanical behavior is complex, according to weld groups geometry, strength, eccentrically loaded and other factors as design considerations. This research conducted to study weld groups of steel construction the eccentrically load. Furthermore, apply the four analytical methods compared.

Fillet weld analysis, there are two main methods, one is elastic method, it is an easy task to use, based on the eccentric force can be moved the center of gravity of the weld group, is resolved into a force acting though the center of gravity of the weld group and a moment. The other is ultimate design, it is complex calculations to analysis, based on the IC location depends upon the geometry of the weld group and the location and direction of the loading. Theoretically, the force equilibrium equations should be satisfied at the correct IC.

Method of analysis had elastic method, instantaneous center of rotation method, AISC design tables method and Iwankiw’s method, respectively. The instantaneous center of rotation method is the most accurate. Calculation process of the Iwankiw’s method is more easily than instantaneous center of rotation method. However, the most commonly used elastic method is the calculation for the most simple and conservative, but the error is the largest. AISC manuals provide the $C$ coefficients for six specific load inclination angles only, which were derived based on the IC method. For a non-tabulated value have the tendency to linearly interpolate the $C$ coefficient for a nonspecific $\theta$ value. However, this is not totally justifiable.

Based on case, engineers can be selection methods used as a reference design.

Keywords: fillet weld, eccentric load, elastic method, instantaneous center of rotation method, approximate method

1. Objectives and Goals
The fillet weld connection both the eccentric load and the moment. The combined load effect is equivalent to the weld rotating about a specific point called “instantaneous center of rotation” (IC). Furthermore, direct exercise of the IC method is not an easy task as it involves the tedious trial-and-error process.

According to instantaneous center of rotation method, AISC(2010) manuals provide the five basic types of weld groups C coefficients for six specific load inclination angles \((\theta = 0^\circ, 15^\circ, 30^\circ, 45^\circ, 60^\circ, \text{ and } 75^\circ)\) only. Bulter and Kulak (1971), Bulter and Pal (1972), Shermer (1971), Brandt (1982), Kulak and Timler (1984), Lesik and Kennedy (1988, 1990), proposed a method of analysis for predicting the ultimate strength of eccentrically loaded welded connections based on load-deformation relationship of the weld and three equations of in plane static equilibrium. Iwankiw (1987) proposed a relatively easy but rather conservative method to approximate the coefficients C for inclined loads on weld patterns with vertical loads. It is based on algebraic rather than vector addition of connector strengths. Sayankar and Kamankar (2014) were analyzing of the experiment and the elastic method.

The analysis methods for compare accuracy and convenience were elastic method, instantaneous center of rotation method, AISC (2010) design table method and Iwankiw's method, respectively.

2. Methods

Determining the strength of an eccentrically loaded fillet weld connection include the elastic method, instantaneous center of rotation method, AISC design tables method, and Iwankiw’s method, respectively. They are briefly described as follows:

2.1 Elastic Method

The elastic method provided by AISC (2010) manual. The eccentric force can be moved the center of gravity of the weld group, is resolved into a force acting though the center of gravity of the weld group and a moment.

To determine the resultant shear per linear inch of weld, \(r_p\) must be resolved into horizontal components and vertical components, where

\[
    r_{px} = \frac{P \sin \theta}{l} \quad ; \quad r_{py} = \frac{P \cos \theta}{l}
\]

(1)

The shear per linear inch of weld due to the moment, the horizontal and vertical components of \(r_m\) are
where
\[ c_x, c_y = \text{radial distance from center of gravity to point in weld group most remote from center of gravity of horizontal and vertical components} \]
\[ e = \text{eccentricity} \]
\[ I_p = I_x + I_y, \text{polar moment of inertia of the weld group.} \]

The required weld strength \( r \) is therefore determined by

\[ r = \sqrt{(r_{px} + r_{nx})^2 + (r_{py} + r_{ny})^2} \]  

(3)

**2.2 Instantaneous Center of Rotation Method**

The combined effect of this rotation and translation is equivalent to a rotation about a point defined as the instantaneous center of rotation (IC), as shown in Figure 1.

The location of the IC depends upon the geometry of the weld group as well as the direction and point of application of the load. The individual resistance of each weld segment is assumed to act on a line perpendicular to a ray passing through the IC and the centroid of that weld segment, as shown in Figure 2.

![Fig 1: Instantaneous center of rotation (IC)](image)

![Fig 2: Forces on weld element](image)

The total strength of all the weld elements combine to resist the eccentric load and, when the correct location of the instantaneous center of rotation has been selected, the three in plane equations of statics (\( \Sigma F_x = 0, \Sigma F_y = 0 \) and \( \Sigma M = 0 \)) will be satisfied. The nominal shear strength of the weld element is limited by the deformation of the weld segment that first reaches its limit, where

\[ P = 0.6F_{ext}(1.0 + 1.5\sin^{1.5}\theta)[p(1.9 - 0.9p)]^{0.1} \]  

(4)
where

\[ P = \text{nominal shear strength of the weld segment at a deformation, } \Delta, \text{ kips} \]

\[ F_{EXX} = \text{weld electrode strength, ksi.} \]

\[ \theta = \text{load angle measured relative to the weld longitudinal axis, degrees} \]

\[ p = \text{ratio of element deformation, } \Delta_i, \text{ to its deformation at the maximum stress, } \Delta_{mi} \]

\[ r_{cr} = \text{distance from instantaneous center of rotation to weld element with minimum } \Delta_{ui}/r_i \text{ ratio, in.} \]

\[ r_i = \text{distance from instantaneous center of rotation to } i^{th} \text{ weld element, in.} \]

\[ x_i = x \text{ component of } r_i \]

\[ y_i = y \text{ component of } r_i \]

\[ \Delta_i = r_i \times \Delta_{ucr}/r_{cr}, \text{ deformation of the } i^{th} \text{ weld element at an intermediate stress level, linearly proportioned to the critical deformation based on distance from the instantaneous center of rotation, } r_i, \text{ in.} \]

\[ \Delta_{mi} = 0.209(\theta_i+2)^{-0.32}w, \text{ deformation of the } i^{th} \text{ weld element at maximum stress, in.} \]

\[ \Delta_{ucr} = \text{deformation of the weld element with minimum } \Delta_{ui}/r_i \text{ ratio at ultimate stress (rupture), usually in the element furthest from instantaneous center of rotation, in.} \]

\[ \Delta_{ui} = 1.087(\theta_i+6)^{-0.65}w \leq 0.17w, \text{ deformation of the } i^{th} \text{ weld element at ultimate stress (rupture), in.} \]

\[ \theta_i = \text{angle between the longitudinal axis of } i^{th} \text{ weld element and the direction the resultant force acting on the element, degrees} \]

\[ w = \text{weld leg size, in.} \]

The nominal shear strength of the weld group is the sum of the individual strengths of all weld segments. Because of the nonlinear nature of the requisite iterative solution, for sufficient accuracy, a minimum of 20 weld elements for the longest line segment is generally recommended.

### 2.3 AISC (2010) Design Tables Method

To obtain reliable coefficients based on instantaneous center of rotation method that would replace the traditional elastic C-value in eccentric load design tables. AISC(2010) manuals provide the five basic types of weld groups C coefficients for six specific load inclination angles \((\theta = 0^\circ, 15^\circ, 30^\circ, 45^\circ, 60^\circ, \text{ and } 75^\circ)\) only.

For a non-tabulated value, current common practice is to utilize the AISC (2010) table to determine the C coefficient by linear interpolation for convenience and approximation. As per the AISC (2010) design manual, the nominal strength \((R_n)\), of a weld group is determined by...
where

\[ R_n = CC_1Dl \] (5)

Where

\begin{align*}
C &= \text{coefficient tabulated below} \\
C_1 &= \text{electrode strength coefficient} \\
l &= \text{characteristic vertical length of weld group, in.} \\
D &= \text{weld size in sixteenths of an inch}
\end{align*}

2.4 Iwankiw’s Method

A relatively easy but rather conservative method to approximate the coefficients C for inclined loads on weld patterns with vertical loads was proposed by Iwankiw (1987) and subsequently adopted in the AISC (1989) ASD design manual. It is based on algebraic rather than vector addition of connector strengths. As such, the result would be exaggerated or unconservative. Iwankiw’s method is computationally easy and has some merits from the ultimate strength method.

Define \( C_{\text{max}} \) as the maximum concentric weld coefficient.

\[ A = \frac{C_{\text{max}}}{C_0} \geq 1.0 \] (6)

where \( C_0 \) is the tabulated C value corresponding to the vertical loading case. For a particular connection pattern and load eccentricity, A is a constant relative to the load inclination angle (\( \theta \)) and serves as the primary property for the connection geometry.

The approximate eccentricity coefficient \( C_a \) for the inclined load is determined by

\[ \frac{C_a}{C_0} = \frac{\sqrt{\sin \theta + A \cos \theta}}{A} \] (7)

where

\[ C_{\text{max}} = \text{channel weld } f_D(1+2k) \times \text{box weld } f_D(2+2k) \times \text{angle } f_D(1+k) \times \text{Two Bar Weld } f_D(2) \]

\( k \) = parameter defining geometry of weld group

\( f_D = 0.6 \times F_{\text{EXT}} \times (1/16) \times \sqrt{2} / 2 \)

\( C_0 \) = weld groups coefficients C
The minimum $C_a/C_0$ ratio of 1.0 represents the worst case occurring when the applied load is vertical. The allowable inclined eccentric load is then defined as

$$P = C_a CD_l$$

(8)

2.5 Illustrations
Calculating by the above described method and compared with the instantaneous center of rotation method. The results and curves are only given size conditions, when different size then results will be vary.

Case 1. Channel Weld
Referring to Figure 3, for a channel weld group the geometric properties are $l_1=10$ in., $l_2= 5$ in. and $l_3=9.25$ in., respectively. Use 0.375-in. fillet weld and 70-ksi electrodes.

In this example the calculated results, as shown in Figure 4 and Table 1. Compared with instantaneous center of rotation method, the degree of conservatism is 11.41 to 46.95% and 0 to 28.11% for the elastic method and Iwankiw’s method, respectively. The linear interpolation design table method overestimates the strength by 0 to 1.22%.

Case 2. Box Weld
Referring to Figure 5, for a box weld group the geometric properties are $l_1=10$ in., $l_2= 5$ in. and $l_3=10.5$ in., respectively. Use 0.375-in. fillet weld and 70-ksi electrodes.

In this example the calculated results, as shown in Figure 6 and Table 2. Compared with instantaneous center of rotation method, the degree of conservatism is 21.61 to 41.79% and 0 to 31.54% for the elastic method and Iwankiw’s method, respectively. The linear interpolation design table method overestimates the strength by 0 to 1.59%.

Case 3. Angle Weld
Referring to Figure 7, for an angle weld group the geometric properties are $l_1=14$ in., $l_2= 7$ in. and $l_3=12.37$ in., respectively. Use 0.375-in. fillet weld and 70-ksi electrodes.

In this example the calculated results, as shown in Figure 8 and Table 3. Compared with instantaneous center of rotation method, the degree of conservatism is 21.58 to 51.51% and 0 to 36.35% for the elastic method and Iwankiw’s method, respectively. The linear interpolation design table method overestimates the strength by 0 to 1.88%.

Case 4. Two Vertical Bar Weld
Referring to Figure 9, for a channel weld group the geometric properties are $l_1=10$ in., $l_2= 5$ in.
and $l_3=10.5$ in., respectively. Use 0.375-in. fillet weld and 70-ksi electrodes.

In this example the calculated results, as shown in Figure 10 and Table 4. Compared with instantaneous center of rotation method, the degree of conservatism is 33.28 to 48.84% and 0 to 40.18% for the elastic method and Iwankiw’s method, respectively. The linear interpolation design table method overestimates the strength by 0 to 2.85%.

**Case 5. Two Horizontal Bar Weld**

Referring to Figure 11, for a channel weld group the geometric properties are $l_1=5$ in., $l_2=10$ in. and $l_3=17$ in., respectively. Use 0.375-in. fillet weld and 70-ksi electrodes.

In this example the calculated results, as shown in Figure 12 and Table 5.

Compared with instantaneous center of rotation method, the degree of conservatism is 0.06 to 49.54% and 0 to 28.71% for the elastic method and Iwankiw’s method, respectively. The linear interpolation design table method overestimates the strength by 0 to 2.27%.

**3. Conclusion**

The instantaneous center of rotation method is the most accurate. In addition, linearly interpolate the design table method would be more than instantaneous center of rotation method. The above methods for comparison, AISC (2010) design tables approximately 60 pages, for a non-tabulated value have the tendency to linearly interpolate the $C$ coefficient for a nonspecific $\theta$ value, which deviation is the smallest, but it must be more than instantaneous center of rotation method almost 2%, although this is not totally justifiable. The Iwankiw’s method deviation is more than instantaneous center of rotation method almost 28% - 40%. The elastic method deviation is the largest, which is more than instantaneous center of rotation method almost 50%, and the calculation for the most simple and conservative.

The Iwankiw’s method initial value ($\theta = 0^\circ$) is the same with instantaneous center of rotation method, yet terminal value ($\theta = 90^\circ$) is the same with elastic method. By the chart illustrates, when angle is larger the curve will be more close to the elastic method, and then the deviation will be greater. Except for Two horizontal bar weld, due to the angle at $\theta =90^\circ$, elastic method and instantaneous center of rotation method is the same. Therefore, the deviation of two horizontal bar weld is less than other section. Based on case, engineers can be selection methods used as a reference design.

**4. References**


Construction, Chicago, IL.


---

**Fig.3:** Channel weld  
**Fig.4:** Differences of $P_A$ by the various methods with case1
Table 1: Differences of $P_n$ by the various methods with case 1

<table>
<thead>
<tr>
<th>angle</th>
<th>IC Method (kips) [1]</th>
<th>Design Table Method (kips) [2]</th>
<th>Elastic Method (kips) [3]</th>
<th>IW Method (kips) [4]</th>
<th>[2-1][1]</th>
<th>[3-1][1]</th>
<th>[4-1][1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>121.18</td>
<td>121.18</td>
<td>67.64</td>
<td>121.18</td>
<td>0.00%</td>
<td>-44.19%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>121.45</td>
<td>122.05</td>
<td>66.76</td>
<td>116.12</td>
<td><strong>0.50%</strong></td>
<td>-45.03%</td>
<td>-4.39%</td>
</tr>
<tr>
<td>10</td>
<td>122.31</td>
<td>122.92</td>
<td>66.38</td>
<td>112.28</td>
<td><strong>0.51%</strong></td>
<td>-45.72%</td>
<td>-8.20%</td>
</tr>
<tr>
<td>15</td>
<td>123.80</td>
<td>123.80</td>
<td>66.49</td>
<td>109.49</td>
<td>0.00%</td>
<td>-46.29%</td>
<td>-11.55%</td>
</tr>
<tr>
<td>20</td>
<td>125.76</td>
<td>126.39</td>
<td>67.07</td>
<td>107.64</td>
<td><strong>0.50%</strong></td>
<td>-46.67%</td>
<td>-14.41%</td>
</tr>
<tr>
<td>25</td>
<td>128.32</td>
<td>128.98</td>
<td>68.17</td>
<td>106.65</td>
<td><strong>0.52%</strong></td>
<td>-46.88%</td>
<td>-16.89%</td>
</tr>
<tr>
<td>30</td>
<td>131.57</td>
<td>131.57</td>
<td>69.80</td>
<td>106.48</td>
<td>0.00%</td>
<td>-46.95%</td>
<td>-19.07%</td>
</tr>
<tr>
<td>35</td>
<td>135.63</td>
<td>136.56</td>
<td>72.05</td>
<td>107.12</td>
<td><strong>0.68%</strong></td>
<td>-46.88%</td>
<td>-21.02%</td>
</tr>
<tr>
<td>40</td>
<td>140.60</td>
<td>141.54</td>
<td>74.99</td>
<td>108.61</td>
<td><strong>0.67%</strong></td>
<td>-46.66%</td>
<td>-22.76%</td>
</tr>
<tr>
<td>45</td>
<td>146.52</td>
<td>146.52</td>
<td>78.76</td>
<td>110.99</td>
<td>0.00%</td>
<td>-46.25%</td>
<td>-24.25%</td>
</tr>
<tr>
<td>50</td>
<td>153.64</td>
<td>155.04</td>
<td>83.52</td>
<td>114.36</td>
<td><strong>0.91%</strong></td>
<td>-45.64%</td>
<td>-25.56%</td>
</tr>
<tr>
<td>55</td>
<td>162.10</td>
<td>163.55</td>
<td>89.53</td>
<td>118.89</td>
<td><strong>0.89%</strong></td>
<td>-44.77%</td>
<td>-26.66%</td>
</tr>
<tr>
<td>60</td>
<td>172.07</td>
<td>172.07</td>
<td>97.13</td>
<td>124.77</td>
<td>0.00%</td>
<td>-43.53%</td>
<td>-27.49%</td>
</tr>
<tr>
<td>65</td>
<td>183.61</td>
<td>185.85</td>
<td>106.81</td>
<td>132.33</td>
<td><strong>1.22%</strong></td>
<td>-41.83%</td>
<td>-27.93%</td>
</tr>
<tr>
<td>70</td>
<td>197.54</td>
<td>199.63</td>
<td>119.30</td>
<td>142.01</td>
<td><strong>1.06%</strong></td>
<td>-39.61%</td>
<td>-28.11%</td>
</tr>
<tr>
<td>75</td>
<td>213.41</td>
<td>213.41</td>
<td>135.62</td>
<td>154.49</td>
<td>0.00%</td>
<td>-36.45%</td>
<td>-27.61%</td>
</tr>
<tr>
<td>80</td>
<td>232.13</td>
<td>157.23</td>
<td>170.80</td>
<td>182.59</td>
<td>-32.26%</td>
<td>-26.42%</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>251.77</td>
<td>185.92</td>
<td>192.59</td>
<td>-26.15%</td>
<td>-23.51%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>259.43</td>
<td>222.74</td>
<td>222.71</td>
<td>-14.14%</td>
<td>-14.16%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig 5: Box weld

Fig 6: Differences of $P_n$ by the various methods with case 2
Table 2: Differences of $P_n$ by the various methods with case 2

<table>
<thead>
<tr>
<th>Angle</th>
<th>IC Method (kips) [1]</th>
<th>Design Table Method (kips) [2]</th>
<th>Elastic Method (kips) [3]</th>
<th>IW Method (kips) [4]</th>
<th>[2-1][1]</th>
<th>[3-1][1]</th>
<th>[4-1][1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>176.01</td>
<td>176.01</td>
<td>112.49</td>
<td>176.01</td>
<td>0.00%</td>
<td>-36.09%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>176.09</td>
<td>177.08</td>
<td>110.55</td>
<td>168.90</td>
<td>0.56%</td>
<td>-37.22%</td>
<td>-4.69%</td>
</tr>
<tr>
<td>10</td>
<td>176.93</td>
<td>178.15</td>
<td>109.46</td>
<td>163.53</td>
<td>0.69%</td>
<td>-38.13%</td>
<td>-7.57%</td>
</tr>
<tr>
<td>15</td>
<td>179.22</td>
<td>179.22</td>
<td>109.18</td>
<td>159.68</td>
<td>0.00%</td>
<td>-39.08%</td>
<td>-10.90%</td>
</tr>
<tr>
<td>20</td>
<td>182.00</td>
<td>183.12</td>
<td>109.69</td>
<td>157.17</td>
<td>0.61%</td>
<td>-39.73%</td>
<td>-13.65%</td>
</tr>
<tr>
<td>25</td>
<td>185.49</td>
<td>187.02</td>
<td>111.00</td>
<td>155.90</td>
<td>0.82%</td>
<td>-40.16%</td>
<td>-15.95%</td>
</tr>
<tr>
<td>30</td>
<td>190.91</td>
<td>190.91</td>
<td>113.18</td>
<td>155.84</td>
<td>0.00%</td>
<td>-40.72%</td>
<td>-18.37%</td>
</tr>
<tr>
<td>35</td>
<td>197.72</td>
<td>199.17</td>
<td>116.30</td>
<td>156.96</td>
<td>0.73%</td>
<td>-41.18%</td>
<td>-20.61%</td>
</tr>
<tr>
<td>40</td>
<td>205.61</td>
<td>207.43</td>
<td>120.47</td>
<td>159.33</td>
<td>0.88%</td>
<td>-41.41%</td>
<td>-22.51%</td>
</tr>
<tr>
<td>45</td>
<td>215.68</td>
<td>215.68</td>
<td>125.88</td>
<td>163.02</td>
<td>0.00%</td>
<td>-41.64%</td>
<td>-24.42%</td>
</tr>
<tr>
<td>50</td>
<td>228.08</td>
<td>230.42</td>
<td>132.77</td>
<td>168.21</td>
<td>1.02%</td>
<td>-41.79%</td>
<td>-26.25%</td>
</tr>
<tr>
<td>55</td>
<td>242.05</td>
<td>245.16</td>
<td>141.46</td>
<td>175.11</td>
<td>1.28%</td>
<td>-41.56%</td>
<td>-27.56%</td>
</tr>
<tr>
<td>60</td>
<td>259.89</td>
<td>259.89</td>
<td>152.45</td>
<td>184.06</td>
<td>0.00%</td>
<td>-41.34%</td>
<td>-29.18%</td>
</tr>
<tr>
<td>65</td>
<td>280.43</td>
<td>284.89</td>
<td>166.40</td>
<td>195.54</td>
<td>1.59%</td>
<td>-40.66%</td>
<td>-30.27%</td>
</tr>
<tr>
<td>70</td>
<td>306.01</td>
<td>309.89</td>
<td>184.30</td>
<td>210.26</td>
<td>1.27%</td>
<td>-39.77%</td>
<td>-31.29%</td>
</tr>
<tr>
<td>75</td>
<td>334.89</td>
<td>334.89</td>
<td>207.58</td>
<td>229.25</td>
<td>0.00%</td>
<td>-38.02%</td>
<td>-31.54%</td>
</tr>
<tr>
<td>80</td>
<td>369.22</td>
<td>238.31</td>
<td>234.16</td>
<td>254.16</td>
<td>0.00%</td>
<td>-35.46%</td>
<td>-31.16%</td>
</tr>
<tr>
<td>85</td>
<td>406.38</td>
<td>279.41</td>
<td>287.28</td>
<td>287.28</td>
<td>0.00%</td>
<td>-31.28%</td>
<td>-29.27%</td>
</tr>
<tr>
<td>90</td>
<td>426.19</td>
<td>334.11</td>
<td>334.06</td>
<td>334.06</td>
<td>-21.61%</td>
<td>-21.62%</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 7: Angle weld

Fig. 8: Differences of $P_n$ by the various methods with case 3
Table 3: Differences of $P_a$ by the various methods with case3

<table>
<thead>
<tr>
<th>angle</th>
<th>IC Method (kips) [1]</th>
<th>Design Table Method (kips) [2]</th>
<th>Elastic Method (kips) [3]</th>
<th>IW Method (kips) [4]</th>
<th>[2-1][1]</th>
<th>[3-1][1]</th>
<th>[4-1][1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>112.71</td>
<td>112.71</td>
<td>57.54</td>
<td>112.70</td>
<td>0.00%</td>
<td>-48.94%</td>
<td>-0.01%</td>
</tr>
<tr>
<td>5</td>
<td>113.12</td>
<td>113.83</td>
<td>57.14</td>
<td>108.55</td>
<td>0.63%</td>
<td>-49.49%</td>
<td>-4.03%</td>
</tr>
<tr>
<td>10</td>
<td>114.23</td>
<td>114.95</td>
<td>57.16</td>
<td>105.48</td>
<td>0.63%</td>
<td>-49.96%</td>
<td>-7.66%</td>
</tr>
<tr>
<td>15</td>
<td>116.07</td>
<td>116.07</td>
<td>57.59</td>
<td>103.33</td>
<td>0.00%</td>
<td>-50.38%</td>
<td>-10.97%</td>
</tr>
<tr>
<td>20</td>
<td>118.68</td>
<td>119.56</td>
<td>58.46</td>
<td>102.03</td>
<td>0.74%</td>
<td>-50.74%</td>
<td>-14.02%</td>
</tr>
<tr>
<td>25</td>
<td>122.11</td>
<td>123.04</td>
<td>59.80</td>
<td>101.53</td>
<td>0.76%</td>
<td>-51.03%</td>
<td>-16.85%</td>
</tr>
<tr>
<td>30</td>
<td>126.53</td>
<td>126.53</td>
<td>61.65</td>
<td>101.81</td>
<td>0.00%</td>
<td>-51.27%</td>
<td>-19.54%</td>
</tr>
<tr>
<td>35</td>
<td>131.99</td>
<td>133.29</td>
<td>64.10</td>
<td>102.87</td>
<td>0.99%</td>
<td>-51.44%</td>
<td>-22.06%</td>
</tr>
<tr>
<td>40</td>
<td>138.68</td>
<td>140.06</td>
<td>67.24</td>
<td>104.76</td>
<td>0.99%</td>
<td>-51.51%</td>
<td>-24.46%</td>
</tr>
<tr>
<td>45</td>
<td>146.82</td>
<td>146.82</td>
<td>71.23</td>
<td>107.55</td>
<td>0.00%</td>
<td>-51.49%</td>
<td>-26.75%</td>
</tr>
<tr>
<td>50</td>
<td>156.65</td>
<td>158.80</td>
<td>76.27</td>
<td>111.37</td>
<td>1.38%</td>
<td>-51.31%</td>
<td>-28.91%</td>
</tr>
<tr>
<td>55</td>
<td>158.43</td>
<td>170.78</td>
<td>82.66</td>
<td>116.38</td>
<td>1.39%</td>
<td>-50.92%</td>
<td>-30.90%</td>
</tr>
<tr>
<td>60</td>
<td>182.75</td>
<td>182.75</td>
<td>90.83</td>
<td>122.85</td>
<td>0.00%</td>
<td>-50.30%</td>
<td>-32.78%</td>
</tr>
<tr>
<td>65</td>
<td>199.56</td>
<td>203.31</td>
<td>101.40</td>
<td>131.14</td>
<td>1.88%</td>
<td>-49.19%</td>
<td>-34.29%</td>
</tr>
<tr>
<td>70</td>
<td>220.04</td>
<td>223.87</td>
<td>115.30</td>
<td>141.78</td>
<td>1.74%</td>
<td>-47.60%</td>
<td>-35.57%</td>
</tr>
<tr>
<td>75</td>
<td>244.43</td>
<td>244.43</td>
<td>133.91</td>
<td>155.59</td>
<td>0.00%</td>
<td>-45.21%</td>
<td>-36.35%</td>
</tr>
<tr>
<td>80</td>
<td>271.84</td>
<td>159.16</td>
<td>173.85</td>
<td>198.67</td>
<td>-41.45%</td>
<td>-36.05%</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>298.89</td>
<td>192.97</td>
<td>233.84</td>
<td>-33.44%</td>
<td>-33.53%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig.9: Two vertical bar weld  

Fig.10: Differences of $P_a$ by the various methods with case4
Table 4: Differences of $P_n$ by the various methods with case 4

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>106.98</td>
<td>106.98</td>
<td>61.13</td>
<td>106.98</td>
<td>0.00%</td>
<td>-42.58%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>107.04</td>
<td>107.64</td>
<td>60.55</td>
<td>103.06</td>
<td>0.55%</td>
<td>-43.43%</td>
<td>-5.72%</td>
</tr>
<tr>
<td>10</td>
<td>107.33</td>
<td>108.29</td>
<td>60.14</td>
<td>100.15</td>
<td>0.70%</td>
<td>-44.08%</td>
<td>-5.87%</td>
</tr>
<tr>
<td>15</td>
<td>108.95</td>
<td>108.95</td>
<td>60.17</td>
<td>98.12</td>
<td>0.00%</td>
<td>-44.77%</td>
<td>-9.93%</td>
</tr>
<tr>
<td>20</td>
<td>111.48</td>
<td>112.10</td>
<td>60.65</td>
<td>96.90</td>
<td>0.56%</td>
<td>-45.60%</td>
<td>-13.08%</td>
</tr>
<tr>
<td>25</td>
<td>114.63</td>
<td>115.26</td>
<td>61.59</td>
<td>96.44</td>
<td>0.55%</td>
<td>-46.27%</td>
<td>-15.87%</td>
</tr>
<tr>
<td>30</td>
<td>118.42</td>
<td>118.42</td>
<td>63.04</td>
<td>96.71</td>
<td>0.00%</td>
<td>-46.77%</td>
<td>-18.33%</td>
</tr>
<tr>
<td>35</td>
<td>122.99</td>
<td>124.59</td>
<td>65.04</td>
<td>97.73</td>
<td>1.31%</td>
<td>-47.12%</td>
<td>-20.54%</td>
</tr>
<tr>
<td>40</td>
<td>128.96</td>
<td>130.77</td>
<td>67.69</td>
<td>99.53</td>
<td>1.41%</td>
<td>-47.51%</td>
<td>-22.82%</td>
</tr>
<tr>
<td>45</td>
<td>136.95</td>
<td>136.95</td>
<td>71.09</td>
<td>102.20</td>
<td>0.00%</td>
<td>-48.09%</td>
<td>-23.37%</td>
</tr>
<tr>
<td>50</td>
<td>146.31</td>
<td>148.61</td>
<td>75.43</td>
<td>105.84</td>
<td>1.57%</td>
<td>-48.45%</td>
<td>-27.66%</td>
</tr>
<tr>
<td>55</td>
<td>157.25</td>
<td>160.27</td>
<td>80.94</td>
<td>110.62</td>
<td>1.92%</td>
<td>-48.53%</td>
<td>-29.65%</td>
</tr>
<tr>
<td>60</td>
<td>171.92</td>
<td>171.92</td>
<td>87.96</td>
<td>116.79</td>
<td>0.00%</td>
<td>-48.84%</td>
<td>-32.07%</td>
</tr>
<tr>
<td>65</td>
<td>189.28</td>
<td>194.67</td>
<td>97.02</td>
<td>124.69</td>
<td>2.85%</td>
<td>-48.74%</td>
<td>-34.12%</td>
</tr>
<tr>
<td>70</td>
<td>211.65</td>
<td>217.42</td>
<td>108.89</td>
<td>134.83</td>
<td>2.72%</td>
<td>-48.55%</td>
<td>-36.29%</td>
</tr>
<tr>
<td>75</td>
<td>240.16</td>
<td>240.16</td>
<td>124.81</td>
<td>148.00</td>
<td>0.00%</td>
<td>-48.03%</td>
<td>-38.37%</td>
</tr>
<tr>
<td>80</td>
<td>276.52</td>
<td>146.73</td>
<td>165.42</td>
<td>-45.94%</td>
<td>-40.18%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>312.34</td>
<td>177.85</td>
<td>189.11</td>
<td>-43.06%</td>
<td>-39.45%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>333.82</td>
<td>222.74</td>
<td>222.71</td>
<td>-33.28%</td>
<td>-31.29%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 11: Two horizontal bar weld

Fig. 12: Differences of $P_n$ by the various methods with case 5
<table>
<thead>
<tr>
<th>angle</th>
<th>IC Method (kips) [1]</th>
<th>Design Table Method (kips) [2]</th>
<th>Elastic Method (kips) [3]</th>
<th>IW Method (kips) [4]</th>
<th>[2-1]/[1]</th>
<th>[3-1]/[1]</th>
<th>[4-1]/[1]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>79.14</td>
<td>79.14</td>
<td>40.41</td>
<td>79.14</td>
<td>0.00%</td>
<td>-48.93%</td>
<td>0.00%</td>
</tr>
<tr>
<td>5</td>
<td>79.26</td>
<td>79.85</td>
<td>40.32</td>
<td>77.05</td>
<td>0.62%</td>
<td>-49.26%</td>
<td>-2.91%</td>
</tr>
<tr>
<td>10</td>
<td>80.06</td>
<td>80.36</td>
<td>40.53</td>
<td>75.63</td>
<td>0.62%</td>
<td>-49.38%</td>
<td>-5.54%</td>
</tr>
<tr>
<td>15</td>
<td>81.27</td>
<td>81.27</td>
<td>41.05</td>
<td>74.81</td>
<td>0.00%</td>
<td>-49.49%</td>
<td>-7.94%</td>
</tr>
<tr>
<td>20</td>
<td>83.02</td>
<td>83.64</td>
<td>41.89</td>
<td>74.58</td>
<td>0.75%</td>
<td>-49.54%</td>
<td>-10.17%</td>
</tr>
<tr>
<td>25</td>
<td>85.36</td>
<td>86.01</td>
<td>43.09</td>
<td>74.91</td>
<td>0.76%</td>
<td>-49.52%</td>
<td>-12.24%</td>
</tr>
<tr>
<td>30</td>
<td>88.38</td>
<td>88.38</td>
<td>44.71</td>
<td>75.83</td>
<td>0.00%</td>
<td>-49.42%</td>
<td>-14.20%</td>
</tr>
<tr>
<td>35</td>
<td>92.18</td>
<td>93.18</td>
<td>46.80</td>
<td>77.37</td>
<td>1.08%</td>
<td>-49.23%</td>
<td>-16.07%</td>
</tr>
<tr>
<td>40</td>
<td>96.91</td>
<td>97.97</td>
<td>49.47</td>
<td>79.58</td>
<td>1.09%</td>
<td>-49.95%</td>
<td>-17.88%</td>
</tr>
<tr>
<td>45</td>
<td>102.77</td>
<td>102.77</td>
<td>52.87</td>
<td>82.58</td>
<td>0.00%</td>
<td>-48.56%</td>
<td>-19.64%</td>
</tr>
<tr>
<td>50</td>
<td>109.99</td>
<td>112.01</td>
<td>57.19</td>
<td>86.49</td>
<td>1.83%</td>
<td>-48.00%</td>
<td>-21.36%</td>
</tr>
<tr>
<td>55</td>
<td>118.97</td>
<td>121.26</td>
<td>62.73</td>
<td>91.53</td>
<td>1.92%</td>
<td>-47.26%</td>
<td>-23.07%</td>
</tr>
<tr>
<td>60</td>
<td>130.50</td>
<td>130.50</td>
<td>69.99</td>
<td>97.98</td>
<td>0.00%</td>
<td>-46.37%</td>
<td>-24.92%</td>
</tr>
<tr>
<td>65</td>
<td>145.16</td>
<td>148.46</td>
<td>79.63</td>
<td>105.28</td>
<td>2.27%</td>
<td>-45.13%</td>
<td>-26.39%</td>
</tr>
<tr>
<td>70</td>
<td>163.25</td>
<td>166.43</td>
<td>92.81</td>
<td>117.08</td>
<td>1.95%</td>
<td>-42.15%</td>
<td>-28.28%</td>
</tr>
<tr>
<td>75</td>
<td>184.39</td>
<td>184.39</td>
<td>111.41</td>
<td>131.45</td>
<td>0.00%</td>
<td>-39.58%</td>
<td>-28.71%</td>
</tr>
<tr>
<td>80</td>
<td>206.34</td>
<td>138.41</td>
<td>151.15</td>
<td></td>
<td>-32.92%</td>
<td>-26.75%</td>
<td></td>
</tr>
<tr>
<td>85</td>
<td>220.75</td>
<td>177.18</td>
<td>179.39</td>
<td></td>
<td>-19.74%</td>
<td>-18.73%</td>
<td></td>
</tr>
<tr>
<td>90</td>
<td>222.88</td>
<td>222.74</td>
<td>222.71</td>
<td></td>
<td>-0.06%</td>
<td>-0.08%</td>
<td></td>
</tr>
</tbody>
</table>
ICEAI-1069

Analysis and Comparison of Compressive Strength of Box Column

Wei T,Hsu*
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: wthsu@cyut.edu.tw

Yu X,Liu
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address:taro615025@gmail.com

Meng H,Cheng
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: eateat66@gmail.com

Rou Y,Liu
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: qaz83675@livemail.tw

Abstract
Torsion resistance, strength and stiffness of box column are very superior, and it's strong double-axis has a high stability, it is widely used in bridges and high floor steel buildings. The current analytical methods can be divided into the AISC-ASD (1989), AISC-LRFD (1999), AISC (2010), AISC (2015) (draft standard), ASD method and LSD method of Taiwan. This study analysis the diversity of each box column buckling strength by using six kinds of standards. The results show that AISC-LRFD (2010) has the highest compressive strength and the most economical result, the results also shown that the ASD method developed by Taiwan has the most conservative result. Through those comprehensive comparisons of economic and rational of each standards, it can provide a reference for engineers.

Keywords: box column, steel structure, allowable strength design, Load and Resistance Factor Design

1. Background
Steel structures are one of the major materials in bridge engineering, it’s an uniform material that can be used repeatedly, and the strength, ductility and toughness was high, easy quality control and short construction period. The compression member used in the bridge structure generally require a large cross-section, in order to reduce the weight and increase the space utilization, the box column naturally became another choice, because of its tors/ional resistance,
strength and stiffness are very fine, and bidirectional strength has a high stability.

Since the condition of steel section and supports will affect the bearing strength of steel structure, we conducted a study based on AISC-ASD (1989), AISC-LRFD (1999), AISC (2010), ASD method and LSD method of Taiwan, carry out an analysis according to box column section, further to explore the compressive strength and economic efficiency of these standards.

2. Methods
In this study, we analysis the compressive strength and economic benefits of box column by using cross-section of box column.

2.1 AISC-ASD (1989) Design Tables Method
On the gross compact section of axially loaded compression members, when $Kl/r$, the largest effective slender-ness ratio of any unbraced segment is less than $C_c$, the allowable stress is:

$$F_a = \frac{1 - \frac{(Kl/r)^2}{2C_c^2}}{\frac{5}{3} + \frac{3(Kl/r)}{8C_c} - \frac{(Kl/r)^2}{8C_c^2}} F_y$$

(1)

where

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

(2)

On the gross section of axially loaded compression members, when $Kl/r$ exceeds $C_c$, the allowable stress is:

$$F_u = \frac{12\pi^2 E}{25(Kl/r)^2}$$

The maximum residual stress of AISC-ASD (1989) is $0.5F_y$, and it also the dividing point of non-elastic and elastic buckling stress. because impact of residual stress and initial bending moment need to be considered at non-elastic buckling state, so the safety factor is more complex; the nominal elastic buckling strength is calculated by Euler's column buckling formula.

2.2 AISC-LRFD (1999) Design Tables Method
The design strength for flexural buckling of compression members whose elements have
width-thickness ratios less than $\lambda$, limiting width-thickness ratios is $\phi_c P_n$:

$$\phi_c = 0.85$$

$$P_n = A_y F_{cr}$$

(a) For $\lambda \leq 1.5$

$$F_{cr} = (0.658 \lambda^2) F_y$$

(b) For $\lambda > 1.5$

$$F_{cr} = \left[ \frac{0.877}{\lambda^2} \right] F_y$$

Where

$$\lambda_c = \frac{Kl}{r\pi} \sqrt{\frac{F_y}{E}}$$

Where

- $A_y$ = gross area of member, in$^2$ (mm$^2$)
- $F_y$ = specified minimum yield stress, ksi (MPa)
- $E$ = modulus of elasticity, ksi (MPa)
- $K$ = effective length factor
- $l$ = laterally unbraced length of member, in. (mm)
- $r$ = governing radius of gyration about the axis of buckling, in. (mm)

The AISC-LRFD (1999) standard increase the influence of the residual stress to increase the scope of non-elastic, $\lambda_c = 1.5$ is the dividing point for non-elastic and the elastic buckling stress, it consider that column members have a high uncertainty, so it need to employ the strength reduction factor $\phi_c = 0.85$.

### 2.3 AISC (2010) Design Tables Method

The design compressive strength, $\phi_c P_n$, and the allowable compressive strength, $P_n/\Omega_c$, are determined as follows.

The nominal compressive strength, $P_n$, shall be the lowest value obtained based on the applicable limit states of flexural buckling, torsional buckling, and flexural-torsional buckling.

$$\phi_c = 0.90 \text{ (LRFD)} \; ; \; \Omega_c = 1.67 \text{ (ASD)}$$

The nominal compressive strength, $P_n$, shall be determined based on the limit state of flexural buckling.
The critical stress, $F_{cr}$, is determined as follows:

\begin{equation}
F_n = F_{cr} A_g
\end{equation}

(a) When $\frac{KL}{rT} \leq 4.71 \sqrt{\frac{F_y}{E}}$ (or $\frac{F_y}{F_t} \leq 2.25$)

\begin{equation}
F_{cr} = \left[ 0.658 \frac{F_y}{F_t} \right] F_y
\end{equation}

(b) When $\frac{KL}{rT} > 4.71 \sqrt{\frac{F_y}{E}}$ (or $\frac{F_y}{F_t} > 2.25$)

\begin{equation}
F_{cr} = 0.877 F_t
\end{equation}

where

\begin{equation}
F_y = \text{elastic buckling stress determined, ksi (MPa)}
\end{equation}

\begin{equation}
F_t = \frac{\pi^2 E}{(KL/r)^2}
\end{equation}

AISC 2010 simplifies the LRFD and ASD design steps, both of them are using $(KL/r)_{\text{max}}$ or $F_y/F_t = 2.25$ as dividing point to determine the non-elastic and elastic buckling stress, the safety factor of ASD method is corrected to $\Omega_c = 1.67$; the strength reduction factor of LRFD method is corrected to $\phi_c = 0.9$, both of them have improved the economic efficiency.

### 2.4 ASD Method of Taiwan

On the gross compact section of axially loaded compression members, when $KL/r$, the largest effective slender-ness ratio of any unbraced segment is less than $C_c$, the allowable stress is:

\begin{equation}
F_a = (0.6F_y) \left[ 0.6 \left( \frac{KL/r}{C_c} \right)^3 - 1.14 \left( \frac{KL/r}{C_c} \right)^2 - 0.085 \left( \frac{KL/r}{C_c} \right) + 1.0 \right]
\end{equation}

where $C_c$ from equation (2)

On the gross section of axially loaded compression members, when $KL/r$ exceeds $C_c$, the allowable stress is:
The design strength for flexural buckling of compression members whose elements have width-thickness ratios less than $\lambda$, limiting width-thickness ratios is $\phi P_n$:

$$ P_c = \frac{F_y A_g}{\left(KL/r\right)^\frac{1}{2}} (A_g) $$

(13)

2.5 LSD Method of Taiwan

The design strength for flexural buckling of compression members whose elements have width-thickness ratios less than $\lambda$, limiting width-thickness ratios is $\phi P_n$:

$$ \phi = 0.85 $$

$$ P_n = A_g F_{cr} $$

(14)

(c). For $\lambda \leq 1.5$

$$ F_{cr} = (0.211\lambda_c^2 - 0.57\lambda_c^2 - 0.06\lambda_c + 1.0)(F_y) $$

(15)

(d). For $\lambda > 1.5$

$$ F_{cr} = \left[ \frac{0.764}{\lambda_c^2} \right] F_y $$

(16)

where $\lambda_c$ from equation (7)

Both Taiwan’s ASD and LSD method need to consider the slenderness and section firmness of steel member, when the flakiness of member $b/t > \lambda$, and it wasn’t a compact section, it belong to slenderness member, and the formula need to be corrected. In ASD method, $0.5F_y$ was declared as non-elastic and elastic buckling stress; in LRFD method, $\lambda_c = 1.5$ was declared as non-elastic and elastic buckling stress.

2.6 Illustrations

Calculate the available strength with a strong /weak axis unbraced length of 4 m.
The material properties referring to Figure 1 and 2, for a cross-section of box the properties are:

$K_x = K_y = 1.0$, $F_y = 2.5$ tf/cm², $F_u = 4.1$ tf/cm² and $E = 2040$ tf/cm².
The ASD calculated results, as shown in Table 1.

![Fig. 1: HSS 12×10×3/8](image1)

![Fig. 2: Unbraced length](image2)

The LRFD calculated results, as shown in Table 2.

### Table 1: Compare with ASD

<table>
<thead>
<tr>
<th></th>
<th>AISC 1989&lt;sub&gt;ASD&lt;/sub&gt;</th>
<th>ASD/Taiwan</th>
<th>AISC 2010&lt;sub&gt;ASD&lt;/sub&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>ASD</td>
<td>$P_d = F_d \times A_g$</td>
<td>$P_d = F_d \times A_g$</td>
<td>$P_d = P_n \times \Omega_c$</td>
</tr>
<tr>
<td></td>
<td>$= 1.444 \times 508.64$</td>
<td>$= 1.455 \times 508.64$</td>
<td>$= 1252.780 / 1.67$</td>
</tr>
<tr>
<td></td>
<td>$= 734.476 , \psi$</td>
<td>$= 740.071 , \psi$</td>
<td>$= 750.167 , \psi$</td>
</tr>
</tbody>
</table>

AISC 2010<sub>ASD</sub> and ASD/Taiwan error:

$$\frac{\text{AISC 2010<sub>ASD</sub> - ASD/Taiwan}}{\text{AISC 2010<sub>ASD</sub>}} \times 100\% = \frac{750.167 - 740.071}{750.167} \times 100\% = 1.345\%$$

AISC 2010<sub>ASD</sub> and AISC 1989<sub>ASD</sub> error:

$$\frac{\text{AISC 2010<sub>ASD</sub> - AISC 1989<sub>ASD</sub>}}{\text{AISC 2010<sub>ASD</sub>}} \times 100\% = \frac{750.167 - 734.476}{750.167} \times 100\% = 2.092\%$$
Calculate strength of different column length is used ASD as shown in Table 3.

Table. 2: Compare with LRFD

<table>
<thead>
<tr>
<th></th>
<th>AISC 1999\text{LRFD}</th>
<th>LSD</th>
<th>AISC 2010\text{LRFD}</th>
</tr>
</thead>
<tbody>
<tr>
<td>LRFD</td>
<td>$\phi_cF_p = (0.85) \times (1252.730)$ - 1064.820 $\phi'$</td>
<td>$\phi_cF_p = (0.85) \times (1232.943)$ - 1048.002 $\phi'$</td>
<td>$\phi_cF_p = (0.85) \times (1252.730)$ - 1127.502 $\phi'$</td>
</tr>
</tbody>
</table>

AISC 2010\text{LRFD} and LSD error:
$$\frac{\text{AISC 2010\text{LRFD} - LSD}}{\text{AISC 2010\text{LRFD}}} \times 100\% = \frac{1127.502 - 1048.002}{1127.502} \times 100\% = 7.051\%$$

AISC 2010\text{LRFD} and AISC 1999\text{LRFD} error:
$$\frac{\text{AISC 2010\text{LRFD} - AISC 1999\text{LRFD}}}{\text{AISC 2010\text{LRFD}}} \times 100\% = \frac{1127.502 - 1064.820}{1127.502} \times 100\% = 5.559\%$$

Table. 3: Relationship between effective length and strength with ASD

<table>
<thead>
<tr>
<th>L (m)</th>
<th>$KL'$</th>
<th>$\lambda_c$</th>
<th>Fe (tf/m³)</th>
<th>AISC 1989\text{ASD} (tf/m³)</th>
<th>Error (%)</th>
<th>ASD/Taiwan (tf/m³)</th>
<th>Error (%)</th>
<th>AISC 2010\text{ASD} (tf/m³)</th>
<th>Error (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>$\infty$</td>
<td>1.50</td>
<td>0.00</td>
<td>1.50</td>
<td>0.00</td>
<td>1.50</td>
<td>0.00</td>
</tr>
<tr>
<td>150</td>
<td>6.35</td>
<td>0.07</td>
<td>498.98</td>
<td>1.48</td>
<td>0.67</td>
<td>1.49</td>
<td>0.00</td>
<td>1.49</td>
<td>0.00</td>
</tr>
<tr>
<td>300</td>
<td>12.70</td>
<td>0.14</td>
<td>124.74</td>
<td>1.46</td>
<td>1.35</td>
<td>1.47</td>
<td>0.68</td>
<td>1.48</td>
<td>1.48</td>
</tr>
<tr>
<td>450</td>
<td>19.06</td>
<td>0.21</td>
<td>55.44</td>
<td>1.43</td>
<td>2.72</td>
<td>1.45</td>
<td>1.36</td>
<td>1.47</td>
<td>1.47</td>
</tr>
<tr>
<td>600</td>
<td>25.41</td>
<td>0.28</td>
<td>31.19</td>
<td>1.41</td>
<td>2.76</td>
<td>1.41</td>
<td>2.76</td>
<td>1.42</td>
<td>1.42</td>
</tr>
<tr>
<td>750</td>
<td>31.76</td>
<td>0.35</td>
<td>19.96</td>
<td>1.38</td>
<td>2.82</td>
<td>1.38</td>
<td>2.82</td>
<td>1.42</td>
<td>1.42</td>
</tr>
<tr>
<td>900</td>
<td>38.11</td>
<td>0.42</td>
<td>13.86</td>
<td>1.34</td>
<td>3.60</td>
<td>1.33</td>
<td>4.32</td>
<td>1.39</td>
<td>1.39</td>
</tr>
<tr>
<td>1050</td>
<td>44.47</td>
<td>0.50</td>
<td>10.18</td>
<td>1.31</td>
<td>2.96</td>
<td>1.28</td>
<td>5.19</td>
<td>1.33</td>
<td>1.33</td>
</tr>
<tr>
<td>1200</td>
<td>50.82</td>
<td>0.57</td>
<td>7.80</td>
<td>1.27</td>
<td>3.05</td>
<td>1.23</td>
<td>6.11</td>
<td>1.31</td>
<td>1.31</td>
</tr>
<tr>
<td>1350</td>
<td>57.17</td>
<td>0.64</td>
<td>6.16</td>
<td>1.23</td>
<td>2.38</td>
<td>1.18</td>
<td>6.35</td>
<td>1.26</td>
<td>1.26</td>
</tr>
<tr>
<td>1500</td>
<td>63.52</td>
<td>0.71</td>
<td>4.99</td>
<td>1.19</td>
<td>1.65</td>
<td>1.12</td>
<td>7.44</td>
<td>1.21</td>
<td>1.21</td>
</tr>
<tr>
<td>1650</td>
<td>69.87</td>
<td>0.78</td>
<td>4.12</td>
<td>1.15</td>
<td>0.86</td>
<td>1.06</td>
<td>8.62</td>
<td>1.16</td>
<td>1.16</td>
</tr>
</tbody>
</table>
Calculate strength of different column length is used LRFD as shown in Table 4.

\[ \text{Error} = \frac{F_{u,2010,ASD} - F_{u,1989,ASD}}{F_{u,2010,ASD}} \times 100\% ; \quad \frac{F_{u,2010,ASD} - ASD/Taiwan}{F_{u,2010,ASD}} \times 100\% \]

Table 4: Relationship between effective length and strength with LRFD

<table>
<thead>
<tr>
<th>L (m)</th>
<th>KL/r</th>
<th>( \lambda_c )</th>
<th>( Fe ) (tf/m²)</th>
<th>AISC 1999 \text{LR} \text{FD} (tf/m²)</th>
<th>Error (%)</th>
<th>LSD (tf/m²)</th>
<th>Error (%)</th>
<th>AISC 2010 \text{LRFD} (tf/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
<td>0.00</td>
<td>( \infty )</td>
<td>2.12</td>
<td>5.78</td>
<td>2.12</td>
<td>5.78</td>
<td>2.25</td>
</tr>
<tr>
<td>130</td>
<td>6.35</td>
<td>0.07</td>
<td>498.97</td>
<td>2.12</td>
<td>5.78</td>
<td>2.11</td>
<td>6.22</td>
<td>2.25</td>
</tr>
<tr>
<td>300</td>
<td>12.70</td>
<td>0.14</td>
<td>124.74</td>
<td>2.11</td>
<td>5.38</td>
<td>2.08</td>
<td>6.73</td>
<td>2.23</td>
</tr>
<tr>
<td>430</td>
<td>19.06</td>
<td>0.21</td>
<td>35.44</td>
<td>2.09</td>
<td>5.43</td>
<td>2.03</td>
<td>7.24</td>
<td>2.21</td>
</tr>
<tr>
<td>600</td>
<td>25.41</td>
<td>0.28</td>
<td>31.19</td>
<td>2.05</td>
<td>5.96</td>
<td>2.00</td>
<td>8.26</td>
<td>2.18</td>
</tr>
</tbody>
</table>
In this example distinguish between inelastic and elastic region of ASD, as shown in Figure 3.

<table>
<thead>
<tr>
<th>750</th>
<th>31.76</th>
<th>0.35</th>
<th>19.96</th>
<th>2.02</th>
<th>5.61</th>
<th>1.95</th>
<th>8.88</th>
<th>2.14</th>
</tr>
</thead>
<tbody>
<tr>
<td>900</td>
<td>38.11</td>
<td>0.42</td>
<td>13.36</td>
<td>1.97</td>
<td>5.74</td>
<td>1.89</td>
<td>9.57</td>
<td>2.09</td>
</tr>
<tr>
<td>1050</td>
<td>44.47</td>
<td>0.50</td>
<td>10.18</td>
<td>1.92</td>
<td>5.42</td>
<td>1.82</td>
<td>10.34</td>
<td>2.03</td>
</tr>
<tr>
<td>1200</td>
<td>50.82</td>
<td>0.57</td>
<td>7.80</td>
<td>1.86</td>
<td>5.58</td>
<td>1.73</td>
<td>11.17</td>
<td>1.97</td>
</tr>
<tr>
<td>1350</td>
<td>57.17</td>
<td>0.64</td>
<td>6.16</td>
<td>1.79</td>
<td>5.79</td>
<td>1.67</td>
<td>12.11</td>
<td>1.90</td>
</tr>
<tr>
<td>1500</td>
<td>63.52</td>
<td>0.71</td>
<td>4.99</td>
<td>1.72</td>
<td>5.49</td>
<td>1.59</td>
<td>12.64</td>
<td>1.82</td>
</tr>
<tr>
<td>1650</td>
<td>69.87</td>
<td>0.78</td>
<td>4.12</td>
<td>1.65</td>
<td>5.71</td>
<td>1.50</td>
<td>14.29</td>
<td>1.75</td>
</tr>
<tr>
<td>1800</td>
<td>76.23</td>
<td>0.85</td>
<td>3.47</td>
<td>1.57</td>
<td>5.42</td>
<td>1.42</td>
<td>14.46</td>
<td>1.66</td>
</tr>
<tr>
<td>1950</td>
<td>82.58</td>
<td>0.92</td>
<td>2.95</td>
<td>1.49</td>
<td>5.70</td>
<td>1.33</td>
<td>15.82</td>
<td>1.58</td>
</tr>
<tr>
<td>2100</td>
<td>88.93</td>
<td>0.99</td>
<td>2.55</td>
<td>1.41</td>
<td>5.57</td>
<td>1.29</td>
<td>16.11</td>
<td>1.49</td>
</tr>
<tr>
<td>2250</td>
<td>95.28</td>
<td>1.06</td>
<td>2.22</td>
<td>1.33</td>
<td>5.00</td>
<td>1.16</td>
<td>17.14</td>
<td>1.40</td>
</tr>
<tr>
<td>2400</td>
<td>101.64</td>
<td>1.13</td>
<td>1.95</td>
<td>1.24</td>
<td>6.06</td>
<td>1.08</td>
<td>18.18</td>
<td>1.32</td>
</tr>
<tr>
<td>2550</td>
<td>107.99</td>
<td>1.20</td>
<td>1.73</td>
<td>1.16</td>
<td>5.69</td>
<td>1.00</td>
<td>18.70</td>
<td>1.23</td>
</tr>
<tr>
<td>2700</td>
<td>114.34</td>
<td>1.27</td>
<td>1.54</td>
<td>1.08</td>
<td>5.26</td>
<td>0.92</td>
<td>19.30</td>
<td>1.14</td>
</tr>
<tr>
<td>2850</td>
<td>120.69</td>
<td>1.34</td>
<td>1.38</td>
<td>1.00</td>
<td>5.66</td>
<td>0.85</td>
<td>19.81</td>
<td>1.06</td>
</tr>
<tr>
<td>3000</td>
<td>127.04</td>
<td>1.42</td>
<td>1.25</td>
<td>0.92</td>
<td>5.15</td>
<td>0.79</td>
<td>18.56</td>
<td>0.97</td>
</tr>
<tr>
<td>3150</td>
<td>133.40</td>
<td>1.49</td>
<td>1.13</td>
<td>0.84</td>
<td>5.62</td>
<td>0.73</td>
<td>17.98</td>
<td>0.89</td>
</tr>
<tr>
<td>3300</td>
<td>139.75</td>
<td>1.56</td>
<td>1.03</td>
<td>0.77</td>
<td>4.94</td>
<td>0.67</td>
<td>17.28</td>
<td>0.81</td>
</tr>
<tr>
<td>3450</td>
<td>146.10</td>
<td>1.63</td>
<td>0.94</td>
<td>0.70</td>
<td>5.41</td>
<td>0.61</td>
<td>17.57</td>
<td>0.74</td>
</tr>
<tr>
<td>3600</td>
<td>152.45</td>
<td>1.70</td>
<td>0.87</td>
<td>0.65</td>
<td>4.41</td>
<td>0.56</td>
<td>17.65</td>
<td>0.68</td>
</tr>
<tr>
<td>3750</td>
<td>158.81</td>
<td>1.77</td>
<td>0.80</td>
<td>0.60</td>
<td>4.76</td>
<td>0.52</td>
<td>17.46</td>
<td>0.63</td>
</tr>
<tr>
<td>3900</td>
<td>165.16</td>
<td>1.84</td>
<td>0.74</td>
<td>0.55</td>
<td>5.17</td>
<td>0.48</td>
<td>17.24</td>
<td>0.58</td>
</tr>
<tr>
<td>4050</td>
<td>171.51</td>
<td>1.91</td>
<td>0.68</td>
<td>0.51</td>
<td>5.56</td>
<td>0.44</td>
<td>18.32</td>
<td>0.54</td>
</tr>
<tr>
<td>4200</td>
<td>177.86</td>
<td>1.98</td>
<td>0.64</td>
<td>0.47</td>
<td>6.00</td>
<td>0.41</td>
<td>18.00</td>
<td>0.50</td>
</tr>
</tbody>
</table>
In this example distinguish between inelastic and elastic region of LRFD, as shown in Figure 4.

According to Figure 5 from six design curves compare with economy to order AISC-LRFD 2010 > AISC-LRFD 1999 > LSD > AISC-ASD 2010 > AISC-ASD 1989 > ASD method of Taiwan.
3. Conclusion

This study was conducted of compressive strength analysis and inelastic, elastic buckling stress intensity curves analysis of section box column based on AISC-ASD (1989), AISC-LRFD (1999), AISC (2010), ASD and LSD method of Taiwan. The results of analysis can be summed up into the following conclusions:

By calculated the compressive strength of each standards, can found that AISC-ASD (2010) has the highest compressive strength among the ASD methods, and the AISC-LRFD (2010) has the highest compressive strength among the LRFD methods, in the comparison of six standards, the AISC-LRFD (2010) has the highest compressive strength and the best economy efficiency, and the ASD method of Taiwan has the most conservative result.

In the study of six standards, AISC-LRFD (2010) has the highest compressive strength and the
best economy efficiency, so AISC-LRFD (2010) standard is recommended for the box column design.

4. References
ICEAI-1073
The Analysis of I-Shaped for Compression Members

Wei T,Hsu*
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: wthsu@cyut.edu.tw

Rou Y,Liu
Dep. of Construction Engineering, Chaoyang Univ. of Technology, Taiwan
E-mail address: qaz83675@livemail.tw

Abstract
Column only subjected to pure axial pressure in the ideal state, in the structural design, in addition to support the axial load, the column maybe received the bending moment or many uncertainties factors at the same time, so the strength of the structure will fail to achieve range of designs. In order to prevent the structure achieve to the limit state within the estimated term, and to make sure that the column can safely be used at different loading states, it must consider the impact caused by uncertainty factors, force, load during the structural design period, to prevent each possible factor by using different standard, to improve the quality of the structure, and also enhance the safety of the use.

The standard was written based on the latest knowledge and successful experience in the past, it was describing the stress behavior of structure and provided the basic requirement criteria for general use, it can be the reference to allow engineers in the design. In this study, we conducted the existing I-shaped column into comparative analysis, collect existing analytical theory and relevant standards such as AISC-ASD (1989), AISC-LRFD (1999) and AISC (2010) Design Manual, in order to compare the formula and the analysis method used in the standards, and to explore the comparison of symmetric I-column type strut. The comparison results shown that ASD (1989) is more conservative, and ASD (2010) is more economical; LRFD (1999) is more conservative, and LRFD (2010) is more economical.

Keywords: compression、AISC、ASD、LRFD、I-shaped

1. Background
Column as a compression component, it was subjected to the axial pressure through the center of the rod. Commonly known as the column is a component which can support the vertical load, and it is the most efficient member to transfer the direct stress, it can made by wood, brick and steel. Due to advancement of steel manufacturing techniques, column made by steel material will be a better choice.
Although unit weight of steel larger than concrete and other building materials, but its quality uniform, easy control, fast construction and high accuracy, the structure won’t ruptured suddenly when its exceed with loading, and it’s more easily absorbed vibration energy when subjected with dynamic loading. Because all of the loading distributed on the structure will passed to the column, after that passed to the foundation by column, therefore column is an important members of structure.

2. Methods
In order to reduce the uncertainties of structure during the design-using period, and to make sure that structure can withstand the load and deformation in different stress state, the analysis of column is required. In the existing use of the AISC standard, it can be divided into AISC-ASD (1989), AISC-LRFD (1999), AISC (2010).

2.1 AISC-ASD (1989) Allowable Stress Design
On the gross compact section of axially loaded compression members, when $\frac{Kl}{r}$, the largest effective slender-ness ratio of any unbraced segment is less than $C_c$, the allowable stress is:

$$F_a = \frac{1-(\frac{Kl}{r})^2}{2C_c^2} F_y$$

where

$$C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

On the gross section of axially loaded compression members, when $\frac{Kl}{r}$ exceeds $C_c$, the allowable stress is:

$$F_a = \frac{12\pi^2 E}{23(\frac{Kl}{r})^3}$$

AISC-ASD (1989) let the allowable stress as a design criteria, structural behavior let the elastic behavior as consideration. The safety factor will change depending on the length, from short column ($\Omega_c=1.67$) to the column that slenderness ratio equal to $C_c$ ($\Omega_c=1.92$), it may reflect that the initial displacement of column and long column requires a larger safety factor.

2.2 AISC-LRFD (1999) Design Tables Method
The design strength for flexural buckling of compression members whose elements have
width-thickness ratios less than $\lambda$, limiting width-thickness ratios is $\phi_c P_n$:

$$\phi_c = 0.85$$
$$P_n = A_g F_{cr}$$  \hspace{1cm} (4)

(a). For $\lambda \leq 1.5$

$$F_{cr} = (0.658\lambda^2)F_y$$  \hspace{1cm} (5)

(b). For $\lambda > 1.5$

$$F_{cr} = \left[\frac{0.877}{\lambda_i^2}\right]F_y$$  \hspace{1cm} (6)

Where

$$\lambda_i = \frac{KL}{r^2 \pi} \sqrt{\frac{F_y}{E}}$$  \hspace{1cm} (7)

$A_g =$ gross area of member, in.$^2$ (mm$^2$)

$F_y =$ specified minimum yield stress, ksi (MPa)

$E =$ modulus of elasticity, ksi (MPa)

$K =$ effective length factor

$l =$ laterally unbraced length of member, in. (mm)

$r =$ governing radius of gyration about the axis of buckling, in. (mm)

AISC-LRFD (1999) is based on the variability of material strength and the uncertainty of load values to determine the strength reduction factor and load factor, make structure more safety. Strength reduction factor ($\phi_c$) is mainly consider the uncertainty of structural systems or member strength, in order to let the structure have a safety design, the structural strength can’t be overestimated, so the strength reduction factor must less than 1.

2.3 AISC (2010) Design Tables Method

The design compressive strength, $\phi_c P_n$, and the allowable compressive strength, $P_n/\Omega_c$, are determined as follows.

The nominal compressive strength, $P_n$, shall be the lowest value obtained based on the applicable limit states of flexural buckling, torsional buckling, and flexural-torsional buckling.

$$\phi_c = 0.90 \text{ (LRFD)}; \Omega_c = 1.67 \text{ (ASD)}$$

The nominal compressive strength, $P_n$, shall be determined based on the limit state of
The critical stress, $F_{cr}$, is determined as follows:

(a) When $\frac{KL}{r\pi} \leq 4.71 \sqrt{\frac{F_y}{E}}$ (or $\frac{F_y}{F_t} \leq 2.25$)

$$F_{cr} = \left[ 0.658 \frac{F_y}{F_t} \right] F_t$$

(b) When $\frac{KL}{r\pi} > 4.71 \sqrt{\frac{F_y}{E}}$ (or $\frac{F_y}{F_t} > 2.25$)

$$F_{cr} = 0.877 F_t$$

where

$F_y = \text{elastic buckling stress determined, ksi (MPa)}$

$$F_t = \frac{\pi^2 E}{\left( \frac{KL}{r} \right)^2}$$

AISC (2010) not only consider the common problems of strength and load, but also consider the safety factor ($\Omega_c$) and strength reduction factor ($\phi_c$), lead to a more secure, reasonable and economical design. It include the safety factor $\Omega_c = 1.67$ of ASD and strength reduction factor $\phi_c = 0.9$ of LRFD in this standard.

### 2.4 Illustrations

There is a steel column which length of 30ft under an axial load, it's support type was hinged on both side, the cross-section is W14x132 and strong cross-section. Later, the allowable pressure stress was calculated according to AISC-ASD 1989, AISC-LRFD 1999, AISC-ASD 2010 and AISC-LRFD 2010. $F_y = 50$ ksi $\cdot$ $F_u = 65$ ksi $\cdot$ $E = 29000$ ksi $\cdot$ $K = 1.0$
Because of ASD (1989) will directly attributed the safety factor into the formula, therefore, when the structure in the elastic buckling state, the safety factor is located between 1.67 ~ 1.92, while in the non-elastic buckling state, the safety factor is 1.67. For the ASD (2010), regardless of elastic or non-elastic buckling state, the safety factor is 1.67.

**Table 1: Comparison of ASD 1989 and ASD 2010**

<table>
<thead>
<tr>
<th>L (ft)</th>
<th>KL/t</th>
<th>ASD 1989 (F_{cr}/\Omega_c) (ksi)</th>
<th>ASD 2010 (F_{cr}/\Omega_c) (ksi)</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>30</td>
<td>29.94</td>
<td>-0.20%</td>
</tr>
<tr>
<td>75</td>
<td>19.95</td>
<td>28.31</td>
<td>29.08</td>
<td>2.67%</td>
</tr>
<tr>
<td>150</td>
<td>39.89</td>
<td>25.85</td>
<td>26.65</td>
<td>3.02%</td>
</tr>
<tr>
<td>225</td>
<td>59.84</td>
<td>22.74</td>
<td>23.04</td>
<td>1.30%</td>
</tr>
<tr>
<td>300</td>
<td>79.79</td>
<td>19.05</td>
<td>18.80</td>
<td>-1.37%</td>
</tr>
<tr>
<td>375</td>
<td>99.73</td>
<td>14.77</td>
<td>14.47</td>
<td>-2.07%</td>
</tr>
<tr>
<td>450</td>
<td>119.68</td>
<td>10.43</td>
<td>10.49</td>
<td>0.65%</td>
</tr>
<tr>
<td>525</td>
<td>139.63</td>
<td>7.66</td>
<td>7.71</td>
<td>0.65%</td>
</tr>
<tr>
<td>600</td>
<td>159.57</td>
<td>5.86</td>
<td>5.90</td>
<td>0.65%</td>
</tr>
<tr>
<td>675</td>
<td>179.52</td>
<td>4.63</td>
<td>4.66</td>
<td>0.65%</td>
</tr>
<tr>
<td>750</td>
<td>199.47</td>
<td>3.75</td>
<td>3.78</td>
<td>0.65%</td>
</tr>
<tr>
<td>825</td>
<td>219.41</td>
<td>3.10</td>
<td>3.12</td>
<td>0.65%</td>
</tr>
<tr>
<td>900</td>
<td>239.36</td>
<td>2.61</td>
<td>2.62</td>
<td>0.65%</td>
</tr>
<tr>
<td>975</td>
<td>259.31</td>
<td>2.22</td>
<td>2.24</td>
<td>0.65%</td>
</tr>
<tr>
<td>1050</td>
<td>279.26</td>
<td>1.91</td>
<td>1.93</td>
<td>0.65%</td>
</tr>
</tbody>
</table>

Through the comparison of two curves of calculation, we found that there was a slight gap between the two curves, the 0 to 107 in the figure are non-elastic buckling state, the elastic buckling state are upon 107, it's appear as an overlapping curves in the figure, in order to prove
the error between ASD (1989) and ASD (2010), it's shown in the Figure 3 below.

![Graph showing comparison between ASD (1989) and ASD (2010)]

**Fig. 3: Comparison of ASD 1989 and ASD 2010**

In the error plot of ASD (1989) and ASD (2010), the error of ASD (2010) was larger than ASD (1989) when KL/r located between 0 to 59.84, while KL/r was located between 79.79 to 107, the error of ASD (2010) was smaller, when the KL/r was larger than 119.68, the error of ASD (2010) was became larger. The analysis shows that the use of different design specifications should be based different appropriate range.
The Figure 4 shown that there was a slightly error in two curves, although both of the ASD (1989) and ASD (2010) are still in the safe range, but ASD (1989) is more conservative in design, but ASD (2010) is more economical and reasonable.

LRFD (1999) considered the uncertainty strength of compression member is larger than the tension member, so a larger strength reduction factor $\phi_c=0.85$ was applied to the column. In order to make sure the structures can safely be used under different loading states, LRFD (2010) not only consider the common problems of strength and load, but also considered the strength reduction factor $\Phi_c=0.90$. 
The allowable load of LRFD (2010) are 45ksi, meanwhile the LRFD (1999) are 42.5ksi, so LRFD (2010) is more economical, reasonable, but LRFD (1999) is more conservative.

Table 2: Comparison of LRFD 1999 and LRFD 2010

<table>
<thead>
<tr>
<th>L (ft)</th>
<th>KL/τ</th>
<th>LRFD 1999</th>
<th>LRFD 2010</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>3σFσ (ksi)</td>
<td>3σFσ (ksi)</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>42.50</td>
<td>45.00</td>
<td>-6%</td>
</tr>
<tr>
<td>50</td>
<td>13.30</td>
<td>41.95</td>
<td>44.42</td>
<td>-6%</td>
</tr>
<tr>
<td>100</td>
<td>26.60</td>
<td>40.36</td>
<td>42.73</td>
<td>-6%</td>
</tr>
<tr>
<td>150</td>
<td>39.89</td>
<td>37.83</td>
<td>40.06</td>
<td>-6%</td>
</tr>
<tr>
<td>200</td>
<td>53.19</td>
<td>34.56</td>
<td>36.59</td>
<td>-6%</td>
</tr>
<tr>
<td>250</td>
<td>66.49</td>
<td>30.76</td>
<td>32.57</td>
<td>-6%</td>
</tr>
<tr>
<td>300</td>
<td>79.79</td>
<td>26.68</td>
<td>28.23</td>
<td>-6%</td>
</tr>
<tr>
<td>350</td>
<td>93.09</td>
<td>22.55</td>
<td>23.88</td>
<td>-6%</td>
</tr>
<tr>
<td>400</td>
<td>106.38</td>
<td>18.58</td>
<td>19.67</td>
<td>-6%</td>
</tr>
<tr>
<td>450</td>
<td>119.68</td>
<td>14.90</td>
<td>15.77</td>
<td>-6%</td>
</tr>
<tr>
<td>500</td>
<td>132.98</td>
<td>12.07</td>
<td>12.78</td>
<td>-6%</td>
</tr>
<tr>
<td>550</td>
<td>146.28</td>
<td>9.97</td>
<td>10.56</td>
<td>-6%</td>
</tr>
<tr>
<td>600</td>
<td>159.57</td>
<td>8.38</td>
<td>8.87</td>
<td>-6%</td>
</tr>
<tr>
<td>650</td>
<td>172.87</td>
<td>7.14</td>
<td>7.56</td>
<td>-6%</td>
</tr>
<tr>
<td>700</td>
<td>186.17</td>
<td>6.16</td>
<td>6.52</td>
<td>-6%</td>
</tr>
<tr>
<td>750</td>
<td>199.47</td>
<td>5.36</td>
<td>5.68</td>
<td>-6%</td>
</tr>
<tr>
<td>800</td>
<td>212.77</td>
<td>4.71</td>
<td>4.99</td>
<td>-6%</td>
</tr>
<tr>
<td>850</td>
<td>226.06</td>
<td>4.17</td>
<td>4.42</td>
<td>-6%</td>
</tr>
<tr>
<td>900</td>
<td>239.36</td>
<td>3.72</td>
<td>3.94</td>
<td>-6%</td>
</tr>
</tbody>
</table>
This figure are composed by the ASD (1989), ASD (2010), LRFD (1999), LRFD (2010) and the theoretical value, although all of them are within in the safe range, but with a different standard and coefficient, and therefore have different data curve.

The main concern of LRFD is the reliability of steel structure, it’s using the variability of the
material strength and the uncertainly of load to determine the strength reduction factor and load factor, while the ASD method is used of the allowable stress as the design standards, it's using the safety factor to prevent uncertainty. Therefore, LRFD design is more economic and reasonable than ASD designs.

3. Conclusion

The two main factors of I-shaped column design are the load and intensity. Since the column can divide into elastic and non-elastic buckling, in addition to consider the residual stress, it must consider the impact to the column due to initial bending in the buckling behavior. While the relevant factors such as size and length may also affect the strength of the column or limit state. So the consideration of safety factor (Ωc) or the strength reduction factor (ϕc) within the standard can against uncertainty.

In the comparison of ASD (1989) and ASD (2010), because ASD (1989) are directly attributed the safety factor into the equation, therefore, a variation of safety factor between 1.92 to 1.67 used in the standard, but ASD (2010) set the safety factor to 1.67 to all states. Although the standard are all in the safe range, but ASD (1989) is more conservative, ASD (2010) is more economical and reasonable.

In the comparison of LRFD (1999) and LRFD (2010), Σr,Qr≤ϕPn is the basis of safety design, LRFD (1999) considered the reliability of steel structure, so the column strength reduction factor is set to 0.85. LRFD (2010) considered strength and load of the structure, therefore the strength reduction factor is set to 0.90. Although the standard are all in the safe range, but LRFD (1999) is more conservative, LRFD (2010) is more economical and reasonable.

Using steel column must consider residual stress, initial bend and other uncertainties factor, through the collation, analysis and comparison of ASD and LRFD, ASD (1989) and ASD (2010), LRFD (1999) and LRFD (2010), for ensure safety, use and economic of structures. Three representative standards are safety in use, but based on the evolution of design and economic, the use of AISC (2010) is most appropriate.

4. References

ICEAI-1094
Effect of the Moisture Content on the Dynamic Behavior and Seismic Response of Concrete Pier

Baodong Liu
School of Civil Engineering, Beijing Jiaotong University, PR China
E-mail address: baodongliu@vip.sina.com

Rui Xu
School of Civil Engineering, Beijing Jiaotong University, PR China
E-mail address: 14121123@bjtu.edu.cn

Wenjuan Lv
School of Civil Engineering, Beijing Jiaotong University, PR China
E-mail address: paofanjide@163.com

Abstract
For concrete structures under humid conditions, the internal moisture of them must be influenced by the ambient humidity, which leads to the change in the dynamic behavior of the concrete material and structure. Based on the uniaxial hysteretic experiment on the damping energy dissipation of the concrete material with different moisture contents, considering the moisture-related elastic modulus, the moisture-related dynamic characteristics of an actual concrete pier was analyzed using finite element method. The results show that the damping ratio of the concrete material meets an increase trend with the moisture content increasing. The increasing moisture content leads to the growth of the fundamental frequencies of the pier, whereas it has little effect on the vibration modes. The seismic response of the pier with different moisture contents under the fortification intensity 8 (peak ground acceleration is 0.20g) was studied. We concluded that with the moisture content growing, the displacement at the top of the pier declines, while the shearing forces and bending moments at the bottom of the pier decreases first and then slightly increases. The results of the study can provide reference for the seismic design of structures under humid condition.

Keywords: moisture content; dynamic behavior; damping ratio; seismic response

1. Introduction
With the development of science and technology, people’s demands for the structure form, working condition and performance of concrete structures have changed dramatically for the past decades. The structure form has changed from single building structure to complex structure, whose working conditions and load patterns have become more complex.
The dynamic responses of the concrete structure under seismic load are significantly affected by its own dynamic characteristics, which differs in terms of environmental factors (e.g., temperature, humidity and vehicle load).

Damping is one of the important parameters reflecting the energy dissipation of structures and denotes the thermal and deformation energy transformed from vibration energy during the vibration process. The change of damping means essentially the change of energy dissipation performance of structures [Zhang Z. M. et al., 2001]. In order to investigate the damping ratio of the reinforced concrete with different reinforcement ratios, Shi et al. [Shi J. J. et al., 2003] carried out a series of experiments on 18 T-shaped specimens using free vibration method. The test results showed that the reinforcement ratio had an obvious effect on the damping ratio whereas had little effect on the natural frequency. Shang et al. [Shang S. Y. et al., 1993] conducted an experimental study on the damping ratio of the reinforced concrete member with different concrete strengths and found that the concrete strength had little effect on the damping ratio. He et al. [He Y. B. et al., 2006] believed that the main factors affecting the damping energy dissipation of the reinforced concrete member included the strength and size of aggregates, reinforcement ratio, the property of admixture, concrete strength and maximum shearing stress, nevertheless, water cement ratio, stirrup ratio and sand content had little effect on the damping energy dissipation. Ambrosini D et al. [Ambrosini D et al., 2000] indicated that the structural damage could change the dynamic characteristics of structure (e.g., natural frequency, vibration mode and modal damping) to some extent, which can be obtained by dynamic test. Liu et al. [Liu T. J. et al., 2003] developed a kind of damping concrete with satisfactory damping capacity, the damping ratio of which increased 50%-80% compared to that of common concrete. Based on the seismic test of high damping concrete frame, they preliminarily studied the damping mechanism of high damping concrete. The parameter relationship of viscoelastic material under the three-point bending condition was derived, meanwhile, the relation between the damping properties of concrete material and structure was established. Li [Li M., 2010] designed an immersion test on the reinforced concrete column model in order to study the performance of reinforced concrete structures under water immersion. With the analysis on the hysteretic behavior of the column model with various moisture contents, he concluded that the energy dissipation capacity of immersed members showed an increasing tendency.

Many researches have demonstrated that the ambient humidity had notable effect on the microstructure and mechanical properties of concrete material, resulting in the change of the dynamic characteristic and seismic behavior of concrete structures. Yu et al. [Yu Y. G. et al., 2008] established the binary linear regression equation of modal frequency and moisture content according to the test on a two-span continuous composite model beam (5m+5m). The results showed that the modal frequency increased by 0.09%-0.26% when the moisture content
increased by one degree. However, with the linear regression model between modal properties and environmental factors built, Xia et al. [Xia Y. et al., 2006] found that the frequencies had a strong negative correlation with humidity. To compare the modal frequency of bridge structures affected by rainwater with those free from rainwater, Cornwell P. J. et al. [Cornwell P.J. et al., 1999] performed two preliminary tests on the Alamosa Canyon Bridge on a clear day and a rainy day, respectively. The study indicated that the modal frequency data collected on the rainy day fell within the 95% confidence intervals predicted by linear regression model. Combining the experimental analyses on the six concrete simply-supported test beams under different restrained conditions with two types of reinforced concrete bridges, Yang [Yang M. Z., 2014] explored the effects of environmental factors on the free vibration characteristic and damping ratio of the beam bridge. He found out that when the ambient humidity increased by one degree, there was a about 0.04%-0.14% increase in the natural frequency for model beams and a 0.05% increase for the rigid frame bridge, while 0.15% decrease for the simply supported girder bridge. Min et al. [Min Z. H. et al., 2009] processed the monitoring data of the main navigation channel bridge of Donghai Bridge and obtained the statistical results of structure modal parameter and environment variable. Based on coherence analysis and correlation analysis, they revealed the main environmental factors that affected the dynamic characteristics of structure and found that humidity had no obvious effect on modal frequency. Considering the impact of moisture content on the mechanical properties of structure, Gao [Gao C., 2010] analyzed the seismic responses of the concrete pier in deep water with the moisture content and hydrodynamic pressure taken into account comprehensively. The results showed that the displacement of the pier top decreased while the internal forces of the bottom of pier increased when moisture content was considered.

Some scholars have carried out lots of experimental studies on the effect of ambient humidity on the natural vibration characteristics of concrete bridges, however, the conclusions were controversial and the research mechanism was not deep enough, and few scholars applied the above conclusions into the researches on dynamic response and seismic behavior. Therefore, it is essential to investigate the seismic response of concrete structure considering ambient humidity. Based on the previous experiment on the damping energy dissipation of the concrete material with different moisture contents, considering the moisture-related elastic modulus, this paper analyzed the moisture-related dynamic characteristics of an actual concrete pier using finite element method. The results of the study can provide reference for the seismic design of structures under humid condition.

2. Model Description and Establishment
Take the No.11 pier of a bridge as an example [Zhu X. et al., 2007]. The solid pier with rectangular section was casted by C30 concrete, whose mechanical index can be referred to the Code for Design of Concrete Structure [The People’s Republic of China national standard,
2010]. The dimension of cross section is 3m×6m, and the height of pier is 29.7m, as is shown in Fig.1. The superstructure of the bridge is a prestressed concrete simply-supported girder with the height of 4.25m and the effective span length is 51.1m. The mass of the deck system of one span is 501798kg. The bridge was built on the Class II site and classified as Class B bridge, whose characteristic indexes obey the Guidelines for Seismic Design of Highway Bridges (GB50111-2006) [The People's Republic of China national standard, 2009].

According to the Code for Seismic Design of Railway Engineering (GB 50111-2006), in general case, single pier model can be adopted in the seismic design of the pier of the simply-supported girder bridge under seismic action, and the girder is only considered as a lumped mass. In this paper, the pier was simulated using the finite element software Midas Civil. The single pier model was established by 160 solid elements, and the lumped mass on pier top was the mass of the deck system of one span (501798kg). Suppose that the bottom of pier was fixed on the ground. The finite element model is shown as Fig.2.

The seismic response of the pier was analyzed by response spectrum method considering the moisture content. The fortification intensity is 8 degree (peak ground acceleration is 0.20g), whose characteristic indexes obey the Guidelines for Seismic Design of Highway Bridges (GB50111-2006). The reaction curve of the earthquake acceleration is shown in Fig.3 when the damping ratio is chosen 0.05.
3. Results and Discussions

3.1 Dynamic Characteristics of the Pier Considering Moisture Content

Liu et al. [Liu B. D. et al., 2014] presented an experiment to investigate the relation between the moisture content and the static compressive elastic modulus of concrete, which can be expressed by Eq. 1. As the moisture content was no longer increased with immersion time after 140h, the specimen with 4% moisture content was considered as fully saturated approximately.

\[ E = 1982.3 \rho + 25802, \]  

(1)

where \( E \) denotes the modulus of elasticity (MPa), and \( \rho \) denotes the moisture content (%).

In this research, the moisture content of 0%-4% was considered. The elastic modulus of concrete material with different moisture contents can be calculated by Eq. 1, as summarized in Table 1.

<table>
<thead>
<tr>
<th>Moisture content/%</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>( E / \text{MPa} )</td>
<td>25802</td>
<td>27784.3</td>
<td>29766.6</td>
<td>31748.9</td>
<td>33731.2</td>
</tr>
</tbody>
</table>

According to Table 1, the elastic modulus of concrete with different moisture contents was modified, and then the fundamental frequencies were calculated, as shown in Table 2.

<table>
<thead>
<tr>
<th>Moisture content/%</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>First-order frequency/Hz</td>
<td>1.099431</td>
<td>1.140904</td>
<td>1.180902</td>
<td>1.219389</td>
<td>1.257087</td>
</tr>
</tbody>
</table>

The first period of the pier without water immersion is 0.82s according to Zhu’s paper [Zhu X. et al., 2007]. It is notable that the pier is under natural humidity rather than absolutely dry. From Li’s paper [Li M., 2010], we knew that the moisture content of concrete structure under
natural condition is around 1.5%, when the first period of the pier in this paper is 0.86s, which is agree well with Zhu. Thus, the effectiveness of this model is validated. From Table 3, it is found that the increasing moisture content leads to the growth of the fundamental frequency of the pier, whereas it has little effect on the vibration mode. This is mainly because the elastic modulus of concrete is proportional to moisture content, resulting in a growth in the stiffness of the pier.

### 3.2 Seismic Responses of the Pier Considering Moisture Content

In order to study the effect of moisture content on the damping of concrete material, Lv [Lv W. J., 2015] conducted the uniaxial hysteretic experiment on five concrete specimens C1, C2, C3, C4 and C5 (with the moisture contents of 0%, 0.70%, 1.60%, 2.80% and 3.53%, respectively). In terms of the energy dissipation of concrete material with different moisture contents, the relationship between energy dissipation and moisture content was fitted by polynomial, as Eq.2 shows.

\[
\eta = 0.0007\rho^2 + 0.0015\rho + 0.0504,
\]  

(2)

where \(\eta\) is the loss factor of concrete material.

Damping ratio and loss factor are major parameters measuring the damping capacity of structure. When damping ratio is relatively small, there is a certain relationship between them [Beards C. F., 1996] [Ritchie I. G. et al., 1991]:

\[
\eta = 2\zeta,
\]  

(3)

where \(\zeta\) is the damping ratio of concrete material.

In the case of different moisture contents, the contribution of the energy dissipation of concrete material to structural damping, namely the damping ratio of concrete material, can be calculated by Eq.2 and Eq.3, as shown in Table 3.

<table>
<thead>
<tr>
<th>Moisture content (%)</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\zeta)</td>
<td>0.0252</td>
<td>0.0263</td>
<td>0.0281</td>
<td>0.0306</td>
<td>0.0338</td>
</tr>
</tbody>
</table>

Damping ratio has a significant influence on the reaction curve of structure. According to Chinese regulation, the reaction curve needs to be adjusted when damping ratio is not 0.05. Fig.4 illustrates the reaction curves of the earthquake acceleration with different damping ratios.
Comprehensively considering the impact of moisture content on the elastic modulus and damping ratio of concrete, the seismic response of the pier was calculated, as listed in Table 4.

From Table 4, we can concluded that with the moisture content growing, the displacement at the top of the pier declines, while the shearing force and bending moment at the bottom of the pier decrease first and then slightly increase. The turning point is at the moisture content 3%. This is because under the fortification intensity 8 (0.20g), the displacement at the top of the pier is only concerned with elastic modulus and the geometrical moment of inertia, and has nothing to do with the damping ratio. However, the shearing force and bending moment at the bottom of the pier are affected synthetically by the increasing elastic modulus and damping ratio, so the internal forces do not always decrease. Hence, it is essential to makes a specific analysis in light of the actual situation.
4. Conclusions
Considering the moisture-related elastic modulus and damping energy dissipation of the concrete material with different moisture contents comprehensively, this paper presents a case study on the moisture-related dynamic characteristics and seismic response of an actual concrete pier using finite element method. The following conclusions can be drawn:

(1) The increasing moisture content leads to the growth of the fundamental frequency of the pier, whereas it has little effect on the vibration mode.

(2) Under the fortification intensity 8(0.20g), the displacement at the top of the pier declines, while the shearing force and bending moment at the bottom of the pier decrease first and then slightly increase as moisture content growing. It is essential to makes a specific analysis in light of the actual situation.

Acknowledgments
The authors gratefully acknowledge the financial support of National Science Foundation of China (Grant No. 51278031).

References


ICEAI-1213
Pattern Data for Automatic Design of Free Form Panels

Jeeyoung Lim
Department of Architectural Engineering, Kyung Hee University, Republic of Korea
E-mail address: jyounglim@khu.ac.kr

Seunghyun Son
Department of Architectural Engineering, Kyung Hee University, Republic of Korea
E-mail address: sshway6692@naver.com

Wonhyun Cho
Department of Architectural Engineering, Kyung Hee University, Republic of Korea
E-mail address: tomboy922@khu.ac.kr

Sunkuk Kim*
Department of Architectural Engineering, Kyung Hee University, Republic of Korea
E-mail address: kimsukk@khu.ac.kr

Abstract
The external finish pattern of free form buildings determines their aesthetic characteristics. The pattern is defined as free form panels (FFPs) in production and installation stages [1]. Given the characteristics of free form surfaces, FFPs come in various shapes and sizes, which renders surface panelizing more challenging and thus more time-consuming. To solve these problems, many architects turn to such software tools Rhino and CATIA that permit them to express and modify shapes with much freedom when they design finish patterns. However, using these software tools also requires not only significant time and efforts but also seasoned skills. Therefore, it is necessary to develop a method to enable architects to design external finish patterns quickly and easily while considering the aesthetic quality of panel patterns. The purpose of this study is to survey the pattern data for automatic design of free form panels. Using the pattern data defined in this study allows even architects less skilled in software tools to panelize FFPs rapidly and easily.

Keywords: Free form building, Free Form Panel, Panelization, Pattern, Data

1. Introduction
The external finish pattern of free form buildings determines their aesthetic characteristics [1]. The pattern is defined as free form panels (FFPs) in production and installation stages [1,2,3]. Given the characteristics of free form surfaces, FFPs come in various shapes and sizes [4,5],
which renders surface panelizing more challenging and thus more time-consuming [4,6,7]. To solve these problems, many architects turn to such software tools Rhino and CATIA (Computer-aided three-dimensional interactive application) that permit them to express and modify shapes with much freedom when they design finish patterns [6,8]. However, using these software tools also requires not only significant time and efforts but also seasoned skills. Therefore, it is necessary to develop a method to enable architects to design external finish patterns quickly and easily while considering the aesthetic quality of panel patterns.

According to patterns studies, they are the types of design principles and design elements by David A. Lauer studied, surface pattern by Richard M. Proctor, and pattern language by Christopher Alexander [9,10,11,12]. They attempted to define rules governing the aesthetics of natural patterns and building patterns. These rules need to be converted to digital pattern data to enable automatic design of FFPs. The purpose of this study is to survey the pattern data for automatic design of free form panels. Using the pattern data defined in this study allows even architects less skilled in software tools to panelize FFPs rapidly and easily.

2. Preliminary Study

Many architects use such NURBS (Non-Uniform Rational B- Spline)-based digital design tools as Rhino and CATIA that permit them to express and modify shapes with much freedom when they design finish patterns of free form buildings [8,9]. Parametric modeling adopted in these tools are proven in many reference cases to be an effective approach for finish panel pattern design [13]. Parametric modeling is a process based on algorithm that enables the expression of parameters and rules [14,15]. And by using parametric modeling, architects can enter parameters in software tools such as CATIA to create and modify multiple designs at once. Fig. 1 shows free form buildings designed based on parametric modeling. As these free form buildings are observed from the perspective of a pattern, Walt Disney concert hall (Frank O. Gehry, 2003) shows aesthetic features in general, but it does not reveal a clear pattern (a); BMW welt (COOP HIMMELB(L)AU, 2007) features gradation and unity from a free form design perspective (b); Beijing national stadium (Herzog & de Meuron, 2008) shows structural aesthetics, but in the absence of pattern (c); BMW Pavilion (Bernard Franken, 1999) and Zlote Tarasy (Zerde, Arup, 2007) use a repetition pattern (d, e); Gunagzhou Opera (Zaha Hadid, 2010) shows a pattern of repetition, unity, and proportion (f). Most free form buildings designed using parametric modeling feature aesthetics based on rule-based patterns.

According to pattern studies, David A. Lauer defined the types of design principles as unity, emphasis, focal point, scale, proportion, balance, and rhythm, and design elements as line, shape, volume, texture, pattern, illusion of space, illusion of motion, value, and color (Lauer & Pentak, 2011). However, these concepts are duplicated and they are not defined from the perspective of surface. Richard M. Proctor defined the types of surface pattern as half drop
pattern, square pattern, diamond pattern, scale pattern, brick pattern, hexagon pattern, ogee pattern, and triangle pattern, rendering design principles in surface form. However, he classified the surface patterns in reference to the repetition of pattern, applying limited design principles such as repetition and symmetry. In addition, Christopher Alexander discussed patterns from 235 architectural perspectives including independent regions, the distribution of town, and city country fingers, and introduced cases where such patterns were applied (Christopher Alexander, 1977). However, as these patterns are intended to define pattern language for urban and building architectures, they are not readily adaptable to free form building design. These studies attempt to define the aesthetics of rules underlying natural patterns and building patterns. These rules need to be converted to digital pattern data to enable automatic design of FFPs, and pattern design of free form building for such data need to be redefined.

Fig. 1: Free form buildings using parametric modeling techniques [16,17]

3. Generating Concept of Pattern Data for Automatic Design of FFPs
Designing an aesthetic free form building rapidly and easily requires a method for automatic design of FFPs. As stated preliminary study, it was found that free form buildings designed using parametric modeling contained rule-based patterns, and that the patterns defined in the preceding studies could not be rendered available as finish patterns for free form buildings. Therefore, pattern designs in this study are redefined into primary pattern and secondary pattern. The secondary pattern is defined as a variation of primary pattern. The primary patterns are defined into repetition where there are two or more elements that are identical in shape, color, design, or size; gradation where forms change gradually to become smaller or bigger; symmetry where the right and left sides of a form match each other when folded around the central axis; and contrast where the forms constituting a whole do not share commonality but reveals significant differences. Secondary pattern are defined into unity in which the forms constituting a whole are varied, but having common elements such as shape and size; balance in which the right and left sides of a form do not match exactly with each other when folded
around the central axis, but show different shapes or the same quantity; harmony in which two or more elements are not separated from each other but configured with overall uniformity; proportion that determines the relations between different components or between components and a whole in connection with the shape and length; emphasis that underscores a certain part intensely; and rhythm that a pattern of several components repeated at a certain spacing creates. In addition, the pattern of existing free form building is defined as an applied pattern.

Fig. 2 shows patterns found in free form buildings. In terms of primary pattern, Zlote Tarasy shows a pattern of Repetition where triangles are repeated (a); BMW Welt shows a pattern of gradation and proportion where panels become bigger toward the bottom (b); The glass finish panels of BMW Pavilion shows a pattern of symmetry where the right and the left sides match with each other around the central axis (c); and Beijing national stadium shows a pattern of contrast where the surface is curved overall with contrasting sharpness of unorganized longitudinal lines (d). In terms of applied pattern, Yas Hotel features a pattern of unity where triangles of identical shape and different sizes are repeated (e); Incheon International Airport Traffic Control Center features a pattern of balance in which its overall shape and panels have a balance of the bilateral symmetry (f); Kunsthaus Grass shows a design of emphasis in which rectangular panels are repeated with a cylindrical column in the center catching attention (g); Kunsthaus Grass shows a pattern of harmony where emphases are repeated with overall harmony for the whole (h), and GT Tower shows a pattern of rhythm where wave patterns are repeated rhythmically (i). Free form buildings can be designed using a combination of various patterns for each section and such pattern designs can be also defined into different pattern designs.
repetition pattern can be rendered by Fig. 3 (a) coordinates in Fusion 360, a parametric modeling tool. Pattern data generated in this tool is mapped to the finish panels of free form buildings and converted to the coordinates of FFPs. When the pattern data is mapped to a free form building as shown in Fig. 3 (b), coordinate value Z generated by external finish pattern can be estimated.

4. Design-Production Concept of FFPs Using Pattern Data

Fig. 4 shows a brief illustration of the FFPs design-production technique. Pattern data generated by parametric modeling is configured (a) and a free form building is designed using a concept intended by an architect (b). Data of FFPs consisting of the finish panels of the free form building is extracted and entered into a CNC (Computerized Numeric Control) machine (c). Mold shapes are fabricated by the CNC machine (d) and FFPs are produced from the molds (e). Panelization of FFPs should be considered constructability and design (Lee, 2015). Constructability is determined by the capacity of CNC machine and design is subject to the requirements of a designer. Since the designable size grows as constructible size increases, both design and constructability should be considered.

![Fig. 3: The expression of coordinate for pattern data using parametric modeling](image)
Figure 2 (a) describes the design phase of free form building using parametric modeling and the corresponding design algorithm can be applied as shown in Fig. 5. First of all, a free form building is designed by a designer or architect. The concept of pattern design for the building to be designed is determined by an architect who searches and retrieves pattern data from a data library this time. Pattern data references primary pattern, secondary pattern combined from primary patterns, and patterns of other existing free form buildings (applied pattern). These pattern data are processed or mapped to generate finish patterns of free form building. Generated finish patterns are reviewed and, FFPs data can be extracted from them for FFPs production. When they need to be reworked for less-than-satisfactory aesthetic quality, the concept of pattern design should be redefined or pattern data reprocessed.

5. Conclusion
This study surveyed pattern data for automatic design of FFPs that can render the panelization
of free form surface less challenging and design aesthetic free form building. The following conclusions were derived:

First, patterns found that most free form buildings have certain rules and defined by pattern design, which is verified in partial or overall shape of buildings.

Second, it has been verified that a variety of free form buildings can be configured by pattern design data. Pattern design data will be able to be combined with design algorithm enables architects to design aesthetic free form buildings when configuring the partial or overall shape of a building.

Third, it has been verified that pattern design generated from pattern data is mapped to a free form building, and FFPs can be designed automatically to generate external finish patterns.

We surveyed pattern data based on several preceding studies that defined the aesthetics of natural patterns and building patterns, and developed an automatic design algorithm utilizing such pattern data to ensure the aesthetic quality of free form buildings. In addition, it is possible to panelize the finish panels of a building rapidly and easily. Further studies are required in terms of improved applicability of pattern data to free form building design and extraction of data compatible with CNC machine for FFPs production.

6. Acknowledgements
This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2013R1A2A2A01068297).

7. Reference
Choi, U.(2015), A study on the design attributes of urban housing space surface pattern design, Hanyang University of Architectural Engineering, Doctor’s thesis
Kobayashi, M.(2004), Scientific investigation of architectural aesthetics, 52-66
Jabi, W.(2013), Parametric design for architecture
Woddbury, R.(2010), Elements of parametric design
1. Background
Strength design of a small size crane's booms for pick-up truck was performed in this study. Since the stress analysis of the present used booms is very important, it is needed to make them safer structure as possible as we can. A strength analysis of the boom system in movable hydraulic crane is performed using SP(small punch) test and DAFUL.

2. Methods
Stress-strain curve of materials using SP-test and FEM analysis using DAFUL were to verify the safety of the crane. The SP test method using miniaturized small specimen was the most effective test for strength evaluation of the localized region. The boom used ATOS80 as its material, which is kind of high-tensile steel and specimen size was 10 × 10 × 0.5mm. DAFUL has implemented a dynamic analysis algorithm, based on the implicit method. Original CAD hierarchy can be maintained in DAFUL model. Data file must be translated through CATIA file formats.

3. Conclusions
The crane fixed support at the base has a 2500N hoisting weight, a 2.75m span and a 30°- 70° lift. A result of SP test was inputted as various conditions affecting the crane. The stresses were conducted with an FEM tool using DAFUL according to lifting angle. There are about 21,891,909 total nodes and 234,000 elements after meshing. The results are as follows.

1. The ultimate strength of SP test was 714MPa, which is similar to the ultimate strength of ATOS80(780MPa). It is possible to evaluate the stress-strain characteristics compared with that
obtained in tensile test.

2. The maximum stress was 344MPa when the degree is 30°. It is expected that the crane shall be stable compared with the yield strength of 659MPa

Keywords: SP test, small size crane, DAFUL, FEM, strength analysis

4. Acknowledgement

This work (Commercialization of 0.8t mini cranes for pick-up truck, No.2014000114) was supported by Business for Academic-industrial Cooperative establishments funded Korea Small and Medium Business Administration in 2016.
ICEAI-1195
Seismic Performance Evaluation of FCC Reactor Vessel using Response Spectrum Analysis

Jun Young Yim
Division of Mechanical Design Engineering, Chonbuk National University, South Korea
E-mail address: hiseint@hanmail.net

Hee Yong Kang*
Division of Mechanical Design Engineering, Eco-Friendly Machine Parts Design Research center, Chonbuk National University, South Korea
E-mail address: hykang@jbnu.ac.kr

Sung-Mo Yang
Division of Mechanical System Engineering, Chonbuk National University, South Korea
E-mail address: yangsm@jbnu.ac.kr

Dae Su Kim
Division of Mechanical Design Engineering, Chonbuk National University, South Korea
E-mail address: daesuov@jbnu.ac.kr

1. Background
With a growing interest in renewable energy, the demand of Fluid Catalytic Cracking (FCC) Unit is increasing. As the average frequency of occurrence of earthquake increases per year, seismic performance of large structure is required. Generally, to evaluate the seismic performance, the response of seismic load structure can be analyzed -- the times domain analysis and response spectrum analysis are mainly used for this purpose. The objective of this study is to evaluate the seismic performance of FCC Reactor for earthquake in terms of stress under two conditions: the response spectrum analysis on Safety Shutdown Earthquake (SSE) and the dead load without oil.

2. Methods
FCC Unit is largely composed of a reactor and a regenerator. This study investigates on the reactor part where catalytic reaction appears. The 3-D model was used and simplified the part that is least associated with the analysis for the response spectrum analysis. Materials applied to this study were SA387-Gr.12-C1.1 and SA516-70N, which are mostly used for fuselage. The boundary condition constrained the lower and the upper section of the FCC reactor in the x-axis. The boundary condition also constrained the rotation at the x- and the z-axis. The boundary condition constrained the translation and the rotation for all three axis (x, y, and z) at
all four panel points of the spent catalyst stripper. The applied load was dead load and SSE. The load from SSE can be determined from the coefficient of the area and the ground type according to the KBC-2009 seismic load regulation. The design response spectrum, including 3% of the damping factor, was used for SSE at the constrained panel points. Complete Quadratic Combination (CQC) method was used for a mode combination method.

3. Results
Modal analysis of frequency domain of 0 ~ 100 Hz was conducted to get a frequency with over 90% sum of the modal mass coefficient based on KBC-2009. 93% of the modal mass coefficient was found at 56.2Hz frequency. The number of mode used for the analysis was 114. The mode number was acquired from the modal analysis for the seismic performance evaluation of the FCC Reactor by a seismic load. Using this mode number, response spectrum analysis was conducted, and the results from this analysis were compared with the allowable stress of AISC. The result from response spectrum analysis shows that the reactor chamber applying SA387-Gr.12-Cl.1 materials caused a stress of 127.346 MPa. The allowable stress suggested by the current AISC regulation is 220.8 MPa. Moreover, the allowable stress calculated to not exceed 95% of the yield strength of 230 MPa defines the allowable stress as 218.5 MPa. According to our analysis results, the stress was 58% of the allowable stress prescribed at AISC. Thus, FCC reactor is proved to be safe for seismic load, for SSE and dead load application.

4. Acknowledgement
This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, Science and Technology (No.2014R1A1A4A01008713).

Keywords: Fluid Catalytic Cracking (FCC) Reactor, Modal Analysis, Response Spectrum Analysis, Safety Shutdown Earthquake (SSE)
Poster Session (7)  

Biological Sciences (2)  

Thursday, May 12, 2016  15:00-16:00  Room 1008

ICCBES-1087  
Anion Exchanger 1b in Stereocilia Is Required for the Functioning of Mechanotransducer Channels in Lateral-Line Hair Cells of Zebrafish  
Li-Yih Lin | National Taiwan Normal University  
Jiun Lin Horng | Taipei Medical University

ICCBES-1083  
Environmental Monitoring and Development of Distinction Method of Genetically Modified Zoysiagrass  
Bumkyu Lee | National Academy of Agricultural Science  
Soo In Sohn | National Academy of Agricultural Science  
Doh-Won Yun | National Academy of Agricultural Science  
Ancheol Chang | National Academy of Agricultural Science

ICCBES-1088  
Plasma Membrane Ca^{2+} ATPase Is Required for the Functioning of Mechanotransducer Channels in Zebrafish Hair Cells  
Li-Yih Lin | National Taiwan Normal University  
Jiun Lin Horng | Taipei Medical University

ICCBES-1089  
The CD44 Expression of Mesenchymal Stem Cells, Cancer Cells and Fibroblasts on Chitosan  
Ching-Wen Tsai | National Taiwan University  
Tai-Horng Young | National Taiwan University

ICCBES-1107  
Tubacin Inhibits the Replication of Japanese Encephalitis Virus via the Modulation of HSP90 Acetylation and Chaperone Activity  
Cheng-Wen Lin | China Medical University
ICCBES-1153
Genetic Relationship Analysis of Plants in the Genus Jatropha in Thailand Using ISSR Techniques
Pattamon Sangin | Naresuan University
Kuntapong Srisang | Naresuan University

ICCBES-1160
Immunostimulating Activity of Low Molecular Weight Polysaccharides Isolated from Auricularia Auricula-Judae
Hui-Chen Chung | National Chiayi University
Be-Jen Wang | National Chiayi University
Shu-Mei Lin | National Chiayi University

ICCBES-1163
Amelioration of Cadmium Stress in Mustard (Brassica Juncea) Seedlings by Exogenous Application of Ethylenediaminetetraacetic Acid (EDTA)
Jubayer-Al- Mahmud | Kagawa University
Mirza Hasanuzzaman | Sher-e-Bangla Agricultural University
Kamrun Nahar | Kagawa University
Anisur Rahman | Kagawa University
Masayuki Fujita | Kagawa University

ICCBES-1181
Correlation Analysis on Maize to Low Light Intensity under Shading in Agroforestry System in Indonesia
Yuyun Yuwariah | University of Padjadjaran
M. Kadaffi | Universitas Singaperbangsa
M. Syafii | University of Padjadjaran
Dedi Ruswandi | University of Padjadjaran

ICCBES-1192
Variation in Flowering Time in Unpad Maize Collection under Double Cropping Systems
Anne Nuraini | University of Padjadjaran
Kadapi Muhamad | University of Padjadjaran
Dedi Ruswandi | University of Padjadjaran
ICCBES-1194
Morphology and Distribution of Jatropha L. (Euphorbiaceae) in Thailand
Pranee Nangngam | Naresuan University
Charat Chuayna | Phitsanulok Silvicultural Research Station

ICCBES-1208
Roles of Calcium to Alleviate Manganese Toxicity in Sesame Seedlings (Sesamum Indicum L.)
Mohamed Abdullah Adam | Kagawa University
Jubayer-Al- Mahmud | Kagawa University
Kamrun Nahar | Kagawa University
Anisur Rahman | Kagawa University
Masayuki Fujita | Kagawa University
Md. Shahadat Hossain | Kagawa University

ICCBES-1211
Biodiversity of γ-polyglutamate Producing Bacteria from Plant Rhizoplane
Sirirat Siripornvisal | Phranakhon Si Ayutthaya Rajabhat University

ICCBES-1218
Morphology and Swelling Property of Starch Microsphere Prepared from Cassava Starch with Different Degrees of Hydrolysis
Santhanee Puchaarnon | King Mongkut’s University of Technology Thonburi
Parichat Lertprasertphan | King Mongkut’s University of Technology Thonburi
Dudsadee Uttapap | King Mongkut’s University of Technology Thonburi

ICCBES-1219
MicroRNA-1301-mediated RanGAP1 Downregulation Induces BCR-ABL Nuclear Entrapment to Enhance Imatinib Cytotoxicity in Chronic Myeloid Leukemia Cells
Tsungyao Lin | Taipei Medical University
Chwenming Shih | Taipei Medical University
ICCBES-1250
The Functional Properties and Chemopreventive Analysis of Vernonia Amygdalina Extracts
Ker Sin Sim | National Ilan University
Yen Ting Lai | National Ilan University
Shu Rong Hsu | National Ilan University
Yi Chuan Lee | National Ilan University
Hui Chen Hsu | National Ilan University

ICCBES-1258
EGFR-Targeted Micelles Containing Photosensitizers for Imaging and Photothermal Therapy of Colorectal Cancer
Ying-Hsia Shih | National Taiwan University
Tsai-Yueh Luo | Institute of Nuclear Energy Research
Ping-Fang Chiang | Institute of Nuclear Energy Research
Wuu-Jyh Lin | Institute of Nuclear Energy Research
Cheng-Liang Peng | Institute of Nuclear Energy Research
Ming-Jium Shieh | National Taiwan University

ICCBES-1272
Interaction between NS1 and Cellular MAVS Contributes to NS1 Mitochondria Targeting
Masaki Mibayashi | Mount Sinai School of Medicine
Randy Albrecht | Mount Sinai School of Medicine
Yeu-Yang Tseng | National Chung Hsing University
Wei-Li Hsu | National Chung Hsing University
Peter Palese | Mount Sinai School of Medicine

ICCBES-1273
Fractionation of Bioactive Components from Ganoderma Amboinense Using Supercritical Carbon Dioxide Technology
Kuan-Wei Cheng | National Chiayi University
Zer-Ran Yu | Superwell Biotechnology Corporation
Shu-Mei Lin | National Chiayi University
Be-Jen Wang | National Chiayi University
ICCBES-1363
Simulation-Based Analysis of Autophagy Pathway in Eukaryotic Cells
Jinwoong Kim | Seoul National University
Kyungreem Han | Seoul National University
MooYoung Choi | Seoul National University

ICCBES-1377
Antibacterial Actions of Scleractinian Corals Extracts
Pornpimon Kanjanavas | Huachiew Chalermprakiet University
Pornnapa Phalawong | Huachiew Chalermprakiet University
Chalitta Pumruang | Huachiew Chalermprakiet University
Prasan Sangpiboon | Rambhai Barni Rajabhat University

ICCBES-1382
Extraction and Characterization of Gelatin from Snakeskin Gourami (Trichogaster pectoralis) Scale
Chaunpis Jirapong | Huachiew Chalermprakiet University
Alisa Soontornwat | Huachiew Chalermprakiet University
Pornpimon Kanjanavas | Huachiew Chalermprakiet University
Chairat Techavuthiporn | Huachiew Chalermprakiet University

ICCBES-1383
In Vitro gastric and Pancreatic Digestion of Anthocyanins Extracted from Mulberry Fruit
Alisa Soontornwat | Huachiew Chalermprakiet University
Pornpimon Kanjanavas | Huachiew Chalermprakiet University
Chalermchai Wongs Aree | King Mongkut’s University of Technology
Chaunpis Jirapong | Huachiew Chalermprakiet University

ICCBES-1342
Antifungal Activity of Crude Extracts of Some Medicinal Plants against Curvularia lunata, The Pathogen of Dirty Panicle Disease in Rice
Sanit Sawatdikarn | Phranakhon Si Ayutthaya Rajabhat University
ICCBES-1087
Anion Exchanger 1b in Stereocilia Is Required for the Functioning of Mechatransducer Channels in Lateral-Line Hair Cells of Zebrafish

Li-Yih Lin
Department of Life Science, National Taiwan Normal University, Taiwan, ROC
E-mail address: linly@ntnu.edu.tw

Jiun-Lin Horng
Department of Anatomy and Cell Biology, Taipei Medical University, Taiwan, ROC
E-mail address: jlhorng@tmu.edu.tw

1. Background/ Objectives and Goals
The anion exchanger (AE) plays critical roles in physiological processes including CO2 transport and volume regulation in erythrocytes and acid-base regulation in renal tubules. Although expression of the AE in inner-ear hair cells was reported, its specific localization and function are still unclear.

2. Methods
In situ hybridization and immunohistochemistry were applied to localize AE1b in the hair cells of zebrafish lateral line. A non-invasive, scanning ion-selective electrode technique (SIET) was applied to analyze mechatransducer (MET) channel-mediated Ca\(^{2+}\) influx at stereocilia of hair cells of intact fish. Morpholino gene knockdown technique was used to suppress the protein expression of AE1b in zebrafish.

3. Expected Results/ Conclusion/ Contribution
Using in situ hybridization, we found that the AE1b transcript is expressed in lateral-line hair cells of zebrafish larvae. An immunohistochemical analysis with a zebrafish-specific antibody localized AE1b to stereocilia of hair cells, and the expression was eliminated by morpholino knockdown of AE1b. Ca\(^{2+}\) influx was effectively suppressed by AE1b morpholino knockdown and inhibitor (DIDS) treatment. Elevating external Ca\(^{2+}\) (0.2 to 2 mM) neutralized the inhibition of DIDS. Taken together, this study provides solid evidence to show that AE1b in stereocilia is required for the proper functioning of MET channels.

Keywords: Anion exchanger, Zebrafish, Hair cell, Lateral line
1. Background/ Objectives and Goals
The cultivation area and use of genetically modified (GM) crops have been increased continuously over the world. Safe management for the development and commercialization of GM crops is required according to LMO Act in Korea. This study was conducted to setup the environmental monitoring system of GM zoysiagrass.

2. Methods
In this study two GM zoysia grasses were used. GM Zoysia japonica Steud. (event name: JG21) expressing resistance to glufosinate-ammonium has been generated previously. Male sterility and dwarf Z. japonica (event name: JG21-MS) was developed using gamma ray treatment to JG21. The GM zoysia grasses were planted in 4 GMO confined fields, Sungwhan, Ochang, Jeju University and Jeju Namwon. The environmental monitoring for gene flow and distribution of GM zoysiagrass was performed around the confined field trials for 3 years. The confirmation of GM zoysiagrass was used ImmunoStrip test. The distinguish method of JG21 and JG21-MS was developed using RAPD (random amplified polymorphic DNA) method.

3. Expected Results/ Conclusion/ Contribution
Environmental monitoring was conducted in 4 GMO confined fields contained GM zoysiagrass. In the result of monitoring, we could not found any gene flow and distribution of GM zoysiagrass in the 3 fields (Sungwhan, Ochang, Jeju University), but one spill of JG21 was found in the Namwon field. The detected site was 2 m away from the boundary of GMO confine field. We have extended survey range within 1 km radius, but further spill was not found in 129 sites, 846 samples.

JG21-MS event was developed induced random mutation using gamma ray irradiation to JG21. To establish the detection method of JG21-MS we used RAPD method based mRNA, because JG21-MS was randomly mutated in DNA. 56 pairs of 10 mer premade random primer were tested and finally one primer pair was found to distinguish JG21 and JG21-MS.
Seed distribution and transgenes to environmental ecosystem is one of the most important factors in risk assessment and risk management of GM crops. Planning about the methods, duration, and frequency of environmental monitoring is also required for commercial use of GM crops. In this study, spilled zoysiagrass was detected, and this result suggested that continuous monitoring is necessary to detect the occurrence of GM zoysiagrass for preventing genetic contamination in natural environment. The detection method developed in this study should be useful.

Key Words: Environmental Monitoring, Genetically modified, Risk assessment, Zoysiagrass, RAPD
Plasma Membrane Ca\textsuperscript{2+} ATPase Is Required for the Functioning of Mechatransducer Channels in Zebrafish Hair Cells

Jiun-Lin Horng*
Department of Anatomy and Cell Biology, Taipei Medical University, Taiwan
E-mail address: jlhorng@tmu.edu.tw

Li-Yih Lin
Department of Life Science, National Taiwan Normal University, Taiwan
E-mail address: linly@ntnu.edu.tw

1. Background/ Objectives and Goals
The sensory hair cells in mammalian inner ear are responsible for sound transduction. Sound waves deflect hair bundles and open the mechatransducer (MET) channels, which initiate mechatransduction. The MET channels expressed in stereocilia are cation channels with high Ca\textsuperscript{2+} permeability. In mammalian, mutation of Plasma membrane Ca\textsuperscript{2+} ATPase (PMCA) caused hearing loss however the mechanism is not well understood.

2. Methods
In this study, zebrafish lateral line is used as an animal model to investigate the role of PMCA in mechatransduction of hair cell. The protein expression of PMCA was showed in stereocilia of lateral line hair cells in 72 hpf zebrafish larvae. We used the scanning ion-electrode technique (SIET) for functionally assaying MET channel in hair cell.

3. Expected Results/ Conclusion/ Contribution
The MET channel mediated Ca\textsuperscript{2+} influx detected by SIET was suppressed by treatment of PMCA inhibitors (o-vanadate, eosin Y). Morpholino knockdown of PMCA1 also showed reduced MET channel mediated Ca\textsuperscript{2+} influx and abnormal swimming behaviors. These results indicated that PMCA was critical for maintaining the function of MET channel.

Keywords: hair cell, PMCA, MET channel, zebrafish, SIET
ICCBES-1089
The CD44 Expression of Mesenchymal Stem Cells, Cancer Cells and Fibroblasts on Chitosan

Ching-Wen Tsai; Tai-Horng Young
Institute of Biomedical Engineering, College of Medicine and College of Engineering, National Taiwan University, Taiwan
E-mail address: d02548002@ntu.edu.tw

1. Background/ Objectives and Goals
Cells in 3D culture more closely resemble the in vivo situation with regard to environment, and this resemblance would affect gene expressions and the cell behaviors. Chitosan, a positively charged and natural polymer, has good biocompatibility and biodegradable. Differences in cell adhesion and proliferation have been found according to the cell type, environmental pH, and the degree of chitosan deacetylation. There are many articles that prove how cells can form spheroids on chitosan and how their cellular phenotypes and functions are better than that of monolayer cells. In this study, we tested whether mesenchymal stem cells (MSCs) — 3A6, cancer cells – SW620 and fibroblasts – Hs68 could aggregate to form 3D multicellular spheroids on chitosan and analyzed the influence of spheroids formation.

2. Methods
For analyzing these cell spheroids, we should find a reasonable marker to examine. CD44 is used as an identical surface antigen of MSCs, and has also been defined as a marker of cancer stem cells in many tumor entities. In order to compare the effects of different cell populations cultured on chitosan, the CD44 expressions are thus optimal enough to use as comparison. We found that the proliferation, viability, tendency and causes of CD44 expression of cell spheroids on chitosan were affected by the characteristics of each cell population. CD44 expression of 3A6 spheroids and SW620 spheroids was drastically decreased and increased, respectively, while Hs68 spheroids exhibited no significant change during the culture period. We then also found that the causes of CD44 expressions of cell spheroids cultured on chitosan were dependent on the cell types. Expression of CD44 in Hs68 was stationary in any environments. CD44 expression of 3A6 cells was greatly regulated by their niche. The special chemical structure of chitosan polymer was the main reason why CD44 expression of SW620 spheroids decreased on chitosan.

3. Expected Results/ Conclusion/ Contribution
Many researches have established that the differentiation of MSCs is greatly regulated by their niche. In other words, the 3D spheroid culture method could make MSCs aggregate closer, communicate with each other, and greatly improve differentiation efficiency. We found that no
matter what environments 3A6 cells were cultured in, as long as 3A6 cells aggregated to form cell spheroids or were grown in high density, the expression of CD44 decreased. In addition, researchers have studied the response of cancer cells to hypoxia and serum depletion, and observed that cells developed resistant consequential abilities to angiogenesis, irradiation and chemotherapy. However, after experimenting, we thought that hypoxia and serum depletion were not the main reasons that affected the expression of CD44 of SW620 spheroids on chitosan. PVA, unlike chitosan, could not increase the expression of CD44 on SW620 spheroids. The existence of chitosan promoted CD44 expression of SW620 spheroids distinctly. We speculated that the CD44 expression of SW620 spheroids cultured with chitosan was regulated up due to the special chemical structure of chitosan polymer.

By these results and inferences, the CD44 expression of cell spheroids mediated by the interactions between cell-cell and cell-chitosan was proposed. This study demonstrates CD44 is highly related to the basic characteristic of cells, and studying the spheroids on chitosan would help to develop future transplant therapeutic and clinical applications.

Keywords: Chitosan, CD44, mesenchymal stem cells, cancer cells, fibroblasts.
ICCBES-1107

Tubacin Inhibits the Replication of Japanese Encephalitis Virus via the Modulation of HSP90 Acetylation and Chaperone Activity

Cheng-Wen Lin*
Department of Medical Laboratory Science and Biotechnology, China Medical University, Taiwan
Email: cwlin@mail.cmu.edu.tw

Japanese encephalitis virus (JEV) is a mosquito-borne flavivirus that causes severe central nerve system diseases. The study investigates the antiviral activity and its mechanisms of histone deacetylase (HDAC) inhibitors against JEV. HDAC inhibitors including trichostatin A (TSA), valproic acid (VPA), tubastatin (TBSA) and tubacin were examined their inhibitory activity on the JEV replication in vitro. TSA, TBSA, and tubacin, but not VPA, concentration-dependently inhibited JEV-induced cytopathic effect and apoptosis, as well as reduced the production of JEV in vitro. Among these HDAC inhibitors, tubacin, a HDAC6 inhibitor, was the most potent inhibitory activity with an IC50 of less than 1 µM. Tubacin had no effect on virucidal, virus attachment, and viral RNA synthesis, but significantly reduced intracellular infectious virus particles. Importantly, tubacin treatment caused the increase of HSP90 acetylation, and reduced the protein level of HSP90 during JEV infection. HSP90 inhibitors 17AAG and novobiocin also inhibited the JEV production in concentration-dependent manners, reducing the levels of JEV proteins like NS3 and NS5. The results provide the insights for developing the antiviral agents against JEV.
ICCBES-1153
Genetic Relationship Analysis of Plants in the Genus Jatropha in Thailand Using ISSR Techniques

Pattamon Sangin
Department of Biology, Faculty of Science, Naresuan University, Thailand
E-mail address: pattamons@nu.ac.th

Kuntapong Srisang
Department of Biology, Faculty of Science, Naresuan University, Thailand
E-mail address: kunkummy13@outlook.com

Abstract
There are 5 species of Jatropha in Thailand. However, Jatropha curcas is the only one which is attracted as an alternative to biodiesel. It is widely distributed in many areas in Thailand. Therefore, objectives of this study were to determine the genetic relationships among 24 samples of the genus Jatropha using Inter Simple Sequence Repeats (ISSR). A total of 39 ISSR primers were used for initial screening, only 5 primers, MAO UBC808 UBC827 UBC873 and UBC835 were found to give polymorphic patterns. These ISSR primers amplified 54 polymorphic bands (0.35-2.3 Kb). The similarity coefficient using NTSYS pc (version 2.20e) ranged from 0.66-1.00 among J. curcas and interspecific level of Jatropha ranged from 0.472-0.717. The dendogram was constructed base on SHAH clustering technique of UPGMA which divided the 24 samples into 3 groups. Group I consisted of 19 samples of J. curcas and J. multifida which J. curcas (Lampoon, Thailand) was closely related to J. curcas (Laos) with high similarity index was 1.000. Group 2 was J. integerrima (1), J. integerrima (2) and J. gossypifolia formed a group together. Within this group J. integerrima (1) and J. integerrima (2) were closer to each other with high similarity index was 0.943 and group 3 was J. podagrica.

Keywords: Genetic relationship, Jatropha, ISSR technique

Background
Jatropha belonging to the family Euphobiaceae has around 200 species distributed throughout the tropical and subtropical regions of the world. Jatropha is a drought-resistant perennial crop able to grow in a wide range of soils, grows relatively quickly and producing seeds for 50 years. Jatropha curcas is the only one which is attracted as an alternative to biodiesel and it is a native plant of Mexico and Central America region. It has a very high oil content of 40-50% from seed. The oil was found to contain high levels of unsaturated fatty acids, especially oleic and linoleic (Nzikou, et al., 2009).
However, it is very low fruits, uneven ripening and less number of female flowers. Previous studies on *Jatropha* focused on only medical and chemical compound. Therefore, an understanding of population genetic diversity for breeding program is needed.

Recently, molecular markers are a powerful technique for investigate genetic diversity of plants due to independent of the influence of environment. Moreover, molecular markers provide polymorphism that required to measure genetic relationships and genetic diversity in a reliable manner (Murty *et al*., 2013). ISSR technique was developed by Zietkiewicz *et al.* (1994). ISSRs are semi-arbitrary markers amplified by PCR in the presence of one primer complementary to the target microsatellite-primed PCR. Amplification does not require genome sequence information and lead to multilocus and highly polymorphous patterns. Each band corresponds to a DNA sequence delimited by two inverted microsatellites. Like RAPDs, ISSR markers are quick and easy to handle, but they seem to have the reproducibility of simple sequence repeat (SSR) marker because of the longer length of their primers (Bornet and Branchard, 2001). ISSR method has been used to detect genetic diversity of *Jatropha* from Malaysia, Philippine, India and Indonesia (Biabani *et al*., 2013). Hence, the present study was conducted using ISSR technique to reveal the genetic diversity of *Jatropha* in Thailand.

**Material and Methods**

**Plant Samples**

16 accessions of *Jatropha curcas* were collected from Agricultural Research and Developmen in Nakromrachasima and 2 accessions were correct from *Jatropha* farm, Naresuan University. *J. gossypifolia, J. integerrima, J. podagrica, J. multifida and Ricin communis* (outgroup) were collected from many area in Thailand (Table 1)
Total genomic DNA was extracted from the young leaves of twenty-five samples using CTAB method (Dhakshanamoorthy and Selvaraj, 2009). PCR amplification was performed with thirty-nine ISSR primers. Reactions were carried out in a total volume of 20 µl consisting of 20 ng of template DNA, 1X PCR buffer, 2.5 mM MgCl2, 0.1 mM dNTPs, 200 nM primers, 1.0 unit of Taq polymerase and sterile water. Amplifications were made in a Perkin Elmer 9600 thermocycler with an initial denaturing step of 3 min at 94 °C, followed by 35 cycles of 30 s at 94°C, 45 s at 52°C, 1.30 min at 72°C and a final extension of 5 min at 72°C. PCR products were separated by electrophoresis on 1.6% agarose gels in TBE buffer and visualized using ethidium bromide staining.

Data Analysis
DNA fragments were scored as presence (1) or absence (0) for each primer. These scores were used to calculate genetic similarity according to Nei and Li (1997), from which a UPGMA cluster dendogram was constructed using NTSYS-pc 2.20e (Rohlf, 2000)

**Results**

Thirty-nine ISSR primers were used for prescreening assay with six samples, only five primers (Table 2) generated clear band pattern and polymorphism were selected for further analysis. A total of 54 polymorphic bands were found across of six ISSR primers. The number of bands amplified by each primer ranged from 8 to 14 with an average of 10.5 and the fragments ranging from 0.35-2.3 kb. The primer based on the poly (GACA) revealed more polymorphisms than the primer based on any other motif. However, almost the selective primers were composed of dinucleotide repeats. According with many reports studied genetic diversity in plants.

ISSR data were calculated using UPGMA and analysis was done by using NTSYS-pc (Version 2.20e). The similarity index revealed that the species fell in the range of 0.66-1.00 among *J. curcas* and interspecific level of *Jatropha* ranged from 0.472-0.717 (Table 3). Maximum similarity was between *J. curcas* 5 and *J. curcas* 12 (100%), while least similarity were found between *J. curcas* 11 and *J. podagrica*, *J. curcas* 17 and *J. podagrica* (47.2%). The dendrogram (Fig. 1) classified the 24 accessions into three clusters. All accessions of *J. curcas* and *J. multifida* were clustered into group I. Two accessions of *J. curcas* non-toxic had a relatively high genetic diversity (0.849), similarity *J. curcas* 7, 9 and 10 (Chiang-mai, Thailand) and *J. curcas* (Myanmar) were placed within the same sub-clade and two groups were also in accordance with geographical origin.

The similarity index suggested *J. curcas* 5 (Lampoon, Thailand) that was closely related to *J. curcas* 12 (Laos) but difference geographical origin. *J. curcas* was closely related to *J. multifida* and they represented the same number and structure of chromosomes (2n=22) (Sasikala and Paramathama, 2010). The second group contained *J. integerrima* and *J. gossypifolia*. However, in contrast to previous studies on genetic diversity of *J. curcas* using AFLP and ISSR markers showed that *J. integerrima* was genetically more similar to *J. curcas* than the others (Soonthornyatara, et. al., 2015). Group 3 was *J. podagrica*.

In the present study, the genetic variation of *J. curcas* accessions from Thailand and other countries revealed very low genetic variation among the samples. There were a large number of identical samples. According to Shen et al. (2010) represented the usedof AFLP marker to evaluate genetic diversity of *J. curcas* in Hainan, China. The result showed a high similarity. In the same way, Pamidimarri et al. (2010) used AFLP and RAPD markers to evaluate the genetic diversity of 28 samples of *J. curcas* collected from distinct geographical areas in India.
and a high similarity ranged from 0.866 to 1.00. *J. curcas* was considered the ancestral primitive species that represented its morphological distinctive characteristics (Dehgan and Webster, 1979). Our result revealed that it has to import a new *J. curcas* from other counties or increase the genetic diversity of *J. curcas* by induces mutation using chemical reagent.

<table>
<thead>
<tr>
<th>No.</th>
<th>Primer code</th>
<th>Primer sequence(5'-3')</th>
<th>Total bands</th>
<th>Size bands (bp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>UBC808</td>
<td>AGA GAG AGA GAG AGA GC</td>
<td>8</td>
<td>400-2000</td>
</tr>
<tr>
<td>2</td>
<td>UBC827</td>
<td>ACA CAC ACA CAC ACA CG</td>
<td>9</td>
<td>450-1500</td>
</tr>
<tr>
<td>3</td>
<td>UBC835</td>
<td>AGA GAG AGA GAG AGA GYC</td>
<td>12</td>
<td>350-2000</td>
</tr>
<tr>
<td>4</td>
<td>UBC873</td>
<td>GAC AGA CAG ACA GAC A</td>
<td>14</td>
<td>400-2000</td>
</tr>
<tr>
<td>5</td>
<td>MAO</td>
<td>CTC CTC CTC CTC RC</td>
<td>11</td>
<td>400-2300</td>
</tr>
<tr>
<td></td>
<td>total</td>
<td></td>
<td>54</td>
<td>350-2300</td>
</tr>
</tbody>
</table>

Table 2: List of ISSR polymorphic primers sequence, number of polymorphic bands amplified and product size

Table 3: Similarity index of 24 accessions of *Jatropha*
Acknowledgments

This work was financially supported by Naresuan University (R2558C104). We would like to thank Agricultural Research and Development for providing plant samples.

References


ICCBES-1160

Immunostimulating Activity of Low Molecular Weight Polysaccharides Isolated from Auricularia Auricula-Judae

Hui-Chen Chung
Department of Food Science, National Chiayi University, Taiwan, ROC
E-mail address: s0990453@mail.nctu.edu.tw

Be-Jen Wang
Department of Food Science, National Chiayi University, Taiwan, ROC
E-mail address: bejen@mail.nctu.edu.tw

Shu-Mei Lin
Department of Food Science, National Chiayi University, Taiwan, ROC
E-mail address: smlin00@mail.nctu.edu.tw

1. Background/ Objectives and Goals

The polysaccharides from plants or fungus comprise structurally diverse classes of macromolecules and have been shown to possess pharmaceutical and nutraceutical effects, such as antitumor, hypoglycemic and immunobiological activities. The anti-tumoric and immunomodulatory activities of fungus polysaccharides have particularly drawn great attention over the past decades. There is no consensus basic structural requirement specified for fungus polysaccharide bioactivity. However, the biological activities of polysaccharides appear to be influenced by sugar component, chemical modification, degree of branching, and molecular mass. Auricularia auricula-judae is an edible and medicinal fungus known for its anticoagulant, antitumor, hypoglycemic, hypercholesterolemia and immunobiological activities. However, the bioactive constituents, chemical characteristics and acting mechanism of immunomodulatory effect of polysaccharides derived from Auricularia auricula-judae have not been well investigated. Thus, the objectives of the current study were to purify and characterize the polysaccharides of A. auricula-judae that possess immunomodulatory activity on macrophages. A full understanding on the structural and biofunctional properties of the polysaccharides is essential for further application of A. auricula-juda for health-promotion or therapeutic purpose.

2. Methods

Water soluble A. auricula-judae polysaccharides were extracted under high pressure and high temperature (121 °C, 15 lb) followed by ultrafiltration through different nominal molecular weight cut-offs (10 kDa and 50 kDa) polyethersulfone membranes (effective filtration area 41.8 cm²).
The obtained crude extract and the filtrates of ultrafiltration were assigned as AACP, AACP-F1 (≤10 kDa), and AACP-F2 (≤50 kDa), respectively. The molecular weight (MW) of crude extract was determined by gel permeation chromatography. The total carbohydrate and uronic acid contents were determined using the phenol/sulfuric acid and carbazole-sulphuric acid methods. The monosaccharide composition was determined by high-performance liquid chromatography (HPLC) coupled with refractive index detector (RI). The innate immunity modulatory effect of the extracts was evaluated in cultured macrophages. Murine monocyte/macrophages, Raw 264.7 cells, were cultured in the medium supplemented with or without various concentrations (6.25-1000 μg/ml) of AACP, AACP-F1, and AACP-F2 for 24 hours. A group of cells treated with LPS was used as positive control. Cell proliferation and nitric oxide secretion were measured by 3-(4, 5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) assay and Griess reagent method, respectively. The protein level of interleukin (IL)-1β and tumor necrosis factor (TNF)-α released to the culture medium were detected using ELISA kits. The phagocytosis of FITC-labeled polysaccharide samples by macrophages was examined under a fluorescence microscope. Total RNA was isolated from macrophages using Trizol reagent. The gene expression of IL-1β, TNF-α and inducible nitric oxide synthase (iNOS) was determined by RT-PCR and normalized to those of β-actin. The protein expression of iNOS and activation of NF-κB and IKK were detected by western blotting analysis and normalized to GAPDH expression.

3. Expected Results/Conclusion/Contribution

The results showed that the main molecular weight distribution of A. auricular-judae polysaccharide crude extract was at 336 × 10^4 Da, and minor distribution at 247.5 × 10^5 Da and 174.3 × 10^5 Da. AACP, and AACP-F1 were composed of five main monosaccharides including, in order of decreasing retention time, glucose, xylose, mannose, arabinose and ribose. However, ribose was not detected in AACP-F2. The carbohydrate and uronic acid contents in crude polysaccharide (AACP) are higher than those in AACP-F1 or AACP-F2. The results of innate immunity modulation experiments showed that AACP, AACP-F1 and AACP-F2 fractions significantly increased cell proliferation rate and the phagocytosis capability of macrophages. The activation of the macrophages by AACP, AACP-F1, and AACP-F2 supplementation was confirmed by the production of immune mediators including NO, IL-1β and TNF-α which are major mediators produced by activated macrophage. The induction of the mediators was in line with the up-regulation of gene expression of iNOS and the cytokines at both transcription and translation levels. The gene modulation effects of AACP, AACP-F1 and AACP-F2 were likely associated with the activation of NF-κB indicated by phosphorylation degradation of IκB and nuclear translocation of NF-κB. These preliminary results suggested the potential role of AACP and different nominal molecular weight cut-offs extracts in stimulation of innate immunity. The underlying mechanism and potential cell surface receptor involving in AACP signaling in macrophages is of merit further investigation.
Key word: *Auricularia auricula-judae*, polysaccharide, immunomodulatory
ICCBES-1163

Amelioration of Cadmium Stress in Mustard (Brassica Juncea) Seedlings by Exogenous Application of Ethylenediaminetetraacetic Acid (EDTA)

Jubayer-Al-Mahmud\textsuperscript{a,b}, Mirza Hasanuzzaman\textsuperscript{c}, Kamrun Nahar\textsuperscript{a,d}, Anisur Rahman\textsuperscript{a,c}, Masayuki Fujita\textsuperscript{*}

\textsuperscript{a} Laboratory of Plant Stress Responses, Department of Applied Biological Science, Faculty of Agriculture, Kagawa University, Japan
\textsuperscript{b} Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Bangladesh
\textsuperscript{c} Department of Agronomy, Sher-e-Bangla Agricultural University, Bangladesh
\textsuperscript{d} Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh

\textsuperscript{*} Corresponding author: fujita@ag.kagawa-u.ac.jp

1. Background/ Objectives and Goals

Toxic metals are among the major abiotic factors that affects agricultural productivity and human health worldwide. Among the toxic metals cadmium (Cd) is more harmful toxic metal which inhibits growth and physiology of plants. \textit{Brassica} species has inherent capability as metal accumulator. Therefore, in present study performance of mustard (\textit{Brassica juncea} L. cv. BARI Sharisha 11) seedlings was evaluated through its response to Cd stress in combination with a chelator EDTA (ethylenediaminetetraacetic acid).

2. Methods

Mustard (\textit{Brassica juncea} L. cv. BARI Sharisha 11) seedlings were grown semi-hydroponically in growth chamber and 10-d-old seedlings were treated with EDTA (0.5 mM) and Cd (0.5 mM and 1.0 mM CdCl\textsubscript{2}) separately and/or in combination and grown for 72 h. Plant height, biomass, leaf relative water content (RWC), proline (Pro) content, chlorophyll (chl) content, different stress indicators (malondialdehyde, MDA content; hydrogen peroxide, H\textsubscript{2}O\textsubscript{2} content and lipoxynase, LOX activity) and components of glyoxalase pathway were determined as per standard methodology.

3. Results/ Conclusion/ Contribution

Cadmium exposure decreased height, dry weight (DW) and fresh weight (FW) of mustard seedlings, while the application of EDTA improved plant growth by reducing Cd-induced effect of stressed seedlings. Leaf RWC, chl \textit{a}, chl \textit{b} and total chl contents were decreased by both levels of Cd treatment but Pro content increased. Exogenous application of EDTA restored the leaf RWC, chl \textit{a}, chl \textit{b} and total chl content but resulted in further increase of Pro
content of leaves. The imposition of Cd caused marked increase in the MDA content, H₂O₂ content, LOX activity and methylglyoxal (MG) level which inhibited the seedling growth. These inhibitory effects of Cd were significantly recovered by supplementation with EDTA. Gly-I (glyoxalase-I) activity increased while Gly-II (glyoxalase-II) activity decreased under both levels of cadmium stress. EDTA treatment along with Cd stress further increased Gly-I activity but no significant change was observed for Gly-II activity in contrast with Cd stress alone. These results suggest that the exogenous application of EDTA as chelator rendered the plants to be more tolerant to Cd-induced damages.

Keywords: Abiotic stress, cadmium, chelator, phytoremediation, reactive oxygen species
Correlation Analysis on Maize to Low Light Intensity under Shading in Agroforestry System in Indonesia

Yuyun Yuwariah, D. Ruswandi*
Faculty of Agriculture, Padjadjaran University, Indonesia
dediruswandi2000@yahoo.com

M. Syafii
Universitas Singaperbangsa, Karawang; Indonesia

Abstract
Production of maize in Albizia-agroforestry systems is considered to improve maize production in Indonesia. The success of the selection of new maize cultivars suited to this Albizia-maize system depends on the information of genetic parameter for selection, particularly correlation between important traits related to yield. Study on the correlation of the important traits related to yield in maize inbred lines that is suited to the agroforestry system with Albizia were conducted in areal forests planted with Albizia tree plants that are around 3 years old in Cimalaka, Sumedang, West Java, Indonesia. The study was designed on a split plot design with two replications. The main plot consisted of two cropping system, namely: maize sole cropping system and maize-Albizia agroforestry system. The subplots were ninety-six inbred lines of maize. The characters included days to anthesis, days to silking, anthesis silking interval, plant height, length of nodes, plant diameter, chlorophyll content, leaf area index, leaf area, ear length, ear diameter, number of rows, weight of 1000 seeds and ear weight per plant. Based on the correlation analysis of the traits, in conditions maize sole cropping system, the results showed high correlation between yield component and yield, especially for ear weight per plant, weight of 1000 seeds, wet grain weight per plant, and ratio dry grain weight per plant/ wet grain weight per plant. Correlation of physiology traits to yield, such as chlorophyll content, leaf area index, and leaf area was medium in condition maize-Albizia cropping system. As conclusion, the physiology traits could be used as selection indices for maize tolerance against low intensity under shading in agroforestry.

Keyword: Agroforestry, correlation, maize-Albizia cropping system, multivariate analysis

Introduction
Indonesia is the main important maize producer in South East Asia. Even though, its total maize production reached 18.5 million ton, but its import was not less than 2.7 million ton in year 2015 (BPS, 2015). Demand of maize in Indonesia increase every year as the increase of domestic consumption for food (57%) and feed (34%) and others (9%) (Kasryn, 2002).
However, Ruswandi et al. (2014) reported that national supply could not meet the demand. There are some constrain why it happen to Indonesia, including: low productivity for maize at 4 ton/ha per season; conversion of fertile land to industry in maize center production; changing of global climate causing of drought, flooding in some maize center production; transfer of maize production from fertile land to marginal land; no specific maize hybrid for specific location; and maize hybrid seed is costly.

Extensification by planting maize in marginal land and agroforestry land as maize/Albizia agroforestry system is believed to maintain and increase the national maize production (Syafii et al., 2015; Ruswandi et al., 2014). This solution is possible to be implemented since Indonesia has at least 11 million ha of agroforestry land (Mayrowani & Anshari, 2011). Widiarti (2004) revealed that intercropping of food crop into agroforestry could increase productivity of small farmer owned agroforestry land by increasing land productivity and sustainability, such as: wood 50-150 m³/ha, dry land rice at 2.5 t/ha., maize at 4 t/ha, cassava at 7.5 t/ha, peanut at 1.5 t/ha, chili pepper at 0.5 t/ha, banana at 1500 bunches/ha, pineapple at 4000 fruits/ha/year and papaya at 1500 fruits/ha/year.

Currently, no high yield and shading tolerant maize to Albizia for maize/Albizia agroforestry system are available. Breeding of maize for maize/Albizia agroforestry system is the key to improve national maize production. Shading on susceptible maize can cause deduction of dry weight, starch content, number cell and volume of endosperm. On contrary of such reduction, there are increase of proportion of embryo and endosperm, protein and oil content in seed. Shading is directly delaying of starch form and seed filling period of endosperm. Thus breeding of maize for shading tolerance will direct for maize tolerance to global climate change in which it will maintain self sustain of maize in Indonesia (Ruswandi et al., 2014).

Maize improvements for shading tolerance can applied morphology and physiology associated to high yield, early maturity, and shading tolerance (Yuan et al., 2012). Recently, maize-breeding division, Crop Science Lab. provided and parental line of maize for breeding against shading (Supriatna & Ruswandi, 2013). Various genetic materials had been developed through hybridization and mutation (Ruswandi et al., 2014b) to provide parental for this particular objective. The study on the correlation of the important traits related to yield in maize inbred lines that is suited to the agroforestry system with Albizia are required for breeding against shading.

**Materials and Methods**

The experiment was conducted from April to July 2014 at 3 years old Albizia forestry owned by community in Cibeureum County, Sub-district of Cimalaka, Sumedang District, West Java,
Indonesia at 1200 m above sea level. Genetic materials were planted in Split-plot Design including 72 maize genotype developed by maize breeding division at Crop Science Lab. (Ruswandi et al., 2014b) and 10 lines developed by ICERI, Maros. Analysis of variance (ANOVA) was pursued by 2 factors for 19 traits (fit x by y) and was continued by t test. Multivariate correlation among 19 traits for each factor was done to determine trait(s) associated with yield and to be used as selection index. All analysis used Software JMP verse 5.1.

**Results and Discussion**

Multivariate correlation between traits (s) on shading condition under maize/ Albizia cropping system as well as maize sole cropping system was presented in Table 1 and 2. Correlation analysis can be used to determine trait(s) associated with physiology, morphology, yield components as well as yield in both stress and normal conditions. (Saeesang et al., 2013). Table 1 showed multivariate analysis of morphological, physiological, yield components and yield under shading stress in maize/ Albizia agroforestry. The result showed that correlation between yield component and yield is medium, particularly ear weight (Btong), wet grain yield per plant (BPB), 1000 seed weight (B1000), and harvest index (Ren) ranging from 0.29- 0.39. None of morphological as well as physiological trait(s) possessed high multivariate correlation to yield (-0.07 to 0.08). On contrary to that result, physiological trait such as chlorophyll content (kklo), leaf area (LD), leaf area index (ILD) showed medium multivariate correlation to yield components such as ear weight (Btong), wet grain yield per plant (BPB), 1000 seed weight (B1000), and harvest index (Ren) (0.1 to 0.48). This meant that physiological trait could be proposed as selection index for selection of maize tolerance against shading under maize/ Albizia agroforestry. There are high correlation for days to tasseling (UBJ) and days to silking (UBB) at 0.9229 under shading stress. Thus, leaf area (LD) highly correlated to leaf area index (ILD) at 0.9702. Plant height (TT) showed medium correlated to ear height (Ttong) at 0.5213. Ear diameter (DT) showed highly correlation to ear weight (Btong) and 1000 grain weight (1000B). The result is similar to that research by Yuan et al, (2012). They showed that there are significant correlation between maize plant under shading stress and normal plant on morphological, physiological, agronomical and yield.

Table 2 presented multivariate correlation of reproductive, physiological, morphological, and agronomical traits in maize sole cropping system. Based on the analysis, correlation between yield component (ear weight, grain yield per plant, weight of 1000 seed, and harvest index) and yield were high ranging from 0.38-089. Morphological traits such as: plant height, plant diameter, ear height, ear diameter, and ear length moderately correlated to yield (0.22 - 0.59). Thus, physiological traits, viz. chlorophyll content, leaf area, and leaf area index moderately correlated to yield (0.1 - 0.49). The traits with highly correlated to yield could be used as an index to select maize in sole cropping system.

1202
Table 1. Multivariate analysis of morphological, physiological, yield components and yield under shading stress in maize 'Albina' agroforestry

| Condition | VARI | UBB | ASI | KLiso | LD | LID | TT | Tng | DB | PR | Tpt | Tng | JS | Bt | RFB | 100B | 100R | 100E |
|-----------|------|-----|-----|-------|----|-----|----|-----|----|----|-----|-----|----|----|-----|------|------|------|------|
| UBI       | 1.000| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| VBI       | 0.986| 1.000| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| AGI       | 0.986| 0.986| 1.000| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| UBI       | 0.986| 0.986| 0.986| 1.000 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| ASI       | 0.986| 0.986| 0.986| 0.986 | 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| KLiso     | 0.986| 0.986| 0.986| 0.986 | 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| LD        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| LID       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| TT        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| Tng       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| DB        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986| 0.986|
| PR        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986| 0.986|
| Tpt       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986| 0.986|
| Tng       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986| 0.986|
| JS        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000| 0.986|
| Bt        | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 1.000|
| RFB       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| 100B       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| 100R       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|
| 100E       | 0.986| 0.986| 0.986| 0.986 | 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986| 0.986|

Notes: UBI: days to silking; UBB: days to tasseling; ASI: anthesis-silking interval; KLiso: chlorophyll content; LD: leaf area; LID: leaf area index; TT: plant height; Tng: ear height; DB: plant diameter; PR: node length; Tpt: ear diameter; Tng: ear length; Bt: rows number per ear; Bt: ear weight; BFB: grain weight per plant; 100B: 100 ear weight; RFB: harvest index; 100E: seed water content; 100R: yield.

Conclusion

The physiological traits could be used as selection indices for maize tolerance against low intensity under shading in agroforestry.

Acknowledgements
The authors would like to put into words their appreciation to the Directorate General Higher Education, Ministry of Culture and Education, Republic Indonesia and Universitas Padjadjaran for the research funding through Academic Leadership Grant 2016 to the 1st author and Penelitian Unggulan Perguruan Tinggi and Kompetensi Grant (Hibah PUPT dan HIKOM) 2016 No. 021/SP2/LT/DRPM/II/2016 to the last author.

References


Variation in Flowering Time in Unpad Maize Collection under Double Cropping Systems

Anne Nuraeni, Kadapi Muhamad
1) Lab. of crop science, division of seed technology, University of Padjadjaran, Indonesia

D.Ruswandi
Lab. of crop science, division of plant breeding, University of Padjadjaran, Indonesia
dediruswandi2000@yahoo.com

Abstract
Pollination in Maize (Zea mays L) depends on simultaneous flowering of male and female inflorescences. Environmental conditions may affect on synchronization flowering periods between male and female to ensure pollination, in which could affect on the yield in the end. In this study, we measured the effect of double cropping between maize and soybean on flowering and chlorophyll content. In this research we more emphasize on these two traits among Unpad maize inbred lines in order to select these lines, which could face environmental conditions change, particularly in double cropping. One hundred and twenty four Unpad maize genotypes were used in this investigation and grown them by single and double cropping at an Unpad Field experimental Station in Arjasari, West Java. We detected significant changes on ear flowering variation, while other traits were insignificant. In which our data indicated that variation of ear flowering time by double cropping was smaller than single cropping (Std. Dev; 2.689 vs 3.241). We suspect the competition between maize and soybean affect to this phenomenon and could reveal one of a biological responses in maize, particularly on micro environmental changes such nutrient, water, and temperature. However, we found some of the genotypes were not affected on flowering time (male and female) traits by environmental condition changes such genotype number 108, 110 and 112. We suggest these genotypes could be used as breeding materials and further investigation needed on these lines.

Key words: abiotic stress, flowering time, multiple cropping, maize, multivariate analyses

Introduction
Maize (Zea mays L) is one of the world’s three most important cereal crops (FAO, 2013). In Indonesia, maize is the second most important cereal crop after rice, in terms of the percentage production. However, the growing demand in the region cannot be met despite the increase in domestic production and yield of maize in the last 5 years (2009-2013) (FAO, 2013). Maize is a monoecious plant. In which, male and female flowers are in separate locations.
Male inflorescence (tassels) is growing at the top of the plant whereas female inflorescence (ears) is developing in leaf axils.

The successful of seed set in monoecious as reported by Friedman and Barrett, 2008 was capturing pollen from the same inflorescence and from outcrossing by ears (silk). Furthermore, in lowland tropical maize, variation of flowering in this crops affect to a shortened anthesis-to-silking interval (ASI), in which it was caused by environmental changes (Edmeades et al, 1993; Yuan et al, 2012).

Several environmental conditions may cause variation of flowering in maize such drought (Edmeades et al, 1993), latitude (Liu et al, 2013), and planting density (Prasad, Brook, 2004). Furthermore, Maize as cross-pollinating crops has more genetic diversity within them than inbred varieties. Therefore, according to the previous studies, studying the sensitivities of their breeding system to environmental variation can be important information for breeding programs. In the term of environmental change, we explored how cropping system and the genetic diversity affected flowering in maize.

The objectives of the study are: (i) to identify variation days to flowering and (ii) to select lines which not affect by cropping system based on days to flowering

**Materials and Methods**

This experiment was conducted at field experiment of University Padjadjaran, West Java, Indonesia from October 2015 up to January 2016. The area is upland filed and classified as medium to highland (up to 900 m above sea level). We used maize in UNPAD collection, in which 4 out of 124 are the varieties control (Table 1.). The control varieties were releasing by Seed Company in Indonesia (Table 1). The cropping system experimental in this study is intercropping (double cropping) 1:1 ratio, in which we chose intercropping maize/soybean in this study and as control is monoculture of maize with 75 x 25 cm spacing between maize and 20 x 20 between soybeans. Of 124 maize collections chlorophyll content (ChC) and flowering phenology (tassel and ears) were recorded. For flowering phenology, we monitored and recorded days to tasseling (male flowering) and days to silking (female flowering) according to maize descriptor (IBPGR, 1991).

The statistical analyses of three traits data were conducted using JMP 5.1 (JMP 2000). This software was used to calculate the one-way analysis between the traits and cropping system (Fit x by Y) and multivariate analysis in each cropping system. We used F test two side to observe variation significant between cropping system population and for comparison days to flowering between cropping system we calculated the delta of days to flowering (intercropping – monoculture). Multivariate analysis used
Results and Discussions

One ways analysis showed that chlorophyll content (ChC) and days to tasseling variation between monoculture and intercropping is not significant. This indicated that these traits were not influence by cropping system. Chlorophyll is a pigment that reflects the green colour in plants and is associated with the nutritional status of plants, in which availability of nutrition in soil is the key factors to meet the need nutrition of plant (Ghosh et al., 2004; Kolar and Grewal, 1989).

The insignificant variation in chlorophyll content (ChC) in this study between cropping systems indicated that there was not competition in essential nutrition as important materials on chlorophyll developing (Fig 1). As well as the insignificant variation of days to tasseling between cropping systems showed that there was not competition in living needs. However, our study is successfully revealed that environmental changes could affects to flowering time in maize, particularly in days to silking (Fig 1). This indicated that the diversity of our materials has discovered by cropping system treatment. In addition, in this study we did not found correlation between the chlorophyll content (ChC) and flowering (tassel and ears) which indicated that developing of flowering organ was not influence by the degree of chlorophyll content or we failed to uncovered the chlorophyll content in particular stage has affect to flowering phase (Fig. 2). Due to limitation of the research, we could not reveal the essential competition in environmental condition on days to silking variation due to the complex competition on the element of life in cropping system. However, in this study we found three out of one hundred and twenty four maize in UNPAD collections was not different on days to tasseling and days to silking and could be used as breeding materials and further investigation needed on these lines.

Acknowledgement

The authors would like to put into words their appreciation to the Directorate General Higher Education, Ministry of Culture and Education, Republic Indonesia and Universitas Padjadjaran for the research funding through Academic Leadership Grant 2016 to the 1st author and Penelitian Unggulan Perguruan Tinggi and Kompetnesi Grant (Hibah PUPT dan HIKOM) 2016 No. 021/SP2/LT/DRPM/II/2016 to the last author.

References


Ghosh PK1, Ajay, Bandyopadhyay KK, Manna MC, Mandal KG, Misra AK, Hati KM, 2004 Comparative effectiveness of cattle manure, poultry manure, phosphocompost and
fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. II. Dry matter yield, nodulation, chlorophyll content and enzyme activity. Bioresour Technol. 95: 85-93.

IBPGR. 1993 Descriptors for Maize. International Maize and Wheat Improvement Center, Mexico City/International Board for Plant Genetic Resources, Rome

Kolar JS, Grewal HS, 1989 Phosphorus management of a rice-wheat cropping system. Fertilizer research. 20: 27-32


Prasad RB, Brook RM, 2005 Effect of varying maize densities on intercropped maize and soybean in Nepal, Expl Agric. 41: 365–382

Yuan LZ, Tang JH, Wang XP, Li CH, 2012 QTL analysis of shading sensitive related traits in maize under two shading treatments. Plos One 7: 11

Figure 1. Multivariate analysis between traits in monoculture system (A) and in intercropping system (B)
Figure 2. Fit X by Y analysis between traits and cropping system. Chlorophyll content (A), days to tasseling (B) and days to silking (C). X is indicated genotype no. 108, Y is indicated genotype no. 110 and Z is indicated genotype no. 112.

Table 1. List of UNPAD maize collection used in this study

<table>
<thead>
<tr>
<th>No</th>
<th>Genotype</th>
<th>No</th>
<th>Genotype</th>
<th>No</th>
<th>Genotype</th>
<th>No</th>
<th>Genotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 A</td>
<td>32</td>
<td>3 X 5</td>
<td>63</td>
<td>5 X 13</td>
<td>94</td>
<td>9 x 10</td>
</tr>
<tr>
<td>2</td>
<td>1 X 2</td>
<td>33</td>
<td>3 X 6</td>
<td>64</td>
<td>5 X 14</td>
<td>95</td>
<td>9 X 11</td>
</tr>
<tr>
<td>3</td>
<td>1 X 3</td>
<td>34</td>
<td>3 X 7</td>
<td>65</td>
<td>5 X 15</td>
<td>96</td>
<td>9 X 12</td>
</tr>
<tr>
<td>4</td>
<td>1 X 4</td>
<td>35</td>
<td>3 X 8</td>
<td>66</td>
<td>6 A</td>
<td>97</td>
<td>9 X 13</td>
</tr>
<tr>
<td>5</td>
<td>1 X 5</td>
<td>36</td>
<td>3 X 9</td>
<td>67</td>
<td>6 X 7</td>
<td>98</td>
<td>9 X 14</td>
</tr>
<tr>
<td>6</td>
<td>1 X 6</td>
<td>37</td>
<td>3 X 10</td>
<td>68</td>
<td>6 X 8</td>
<td>99</td>
<td>9 X 15</td>
</tr>
<tr>
<td>7</td>
<td>1 X 7</td>
<td>38</td>
<td>3 X 11</td>
<td>69</td>
<td>6 X 9</td>
<td>100</td>
<td>10 A</td>
</tr>
<tr>
<td>8</td>
<td>1 X 8</td>
<td>39</td>
<td>3 X 12</td>
<td>70</td>
<td>6 X 10</td>
<td>101</td>
<td>10 X 11</td>
</tr>
<tr>
<td>9</td>
<td>1 X 9</td>
<td>40</td>
<td>3 X 13</td>
<td>71</td>
<td>6 X 11</td>
<td>102</td>
<td>10 X 12</td>
</tr>
<tr>
<td>10</td>
<td>1 X 10</td>
<td>41</td>
<td>3 X 14</td>
<td>72</td>
<td>6 X 12</td>
<td>103</td>
<td>10 X 13</td>
</tr>
<tr>
<td>11</td>
<td>1 X 11</td>
<td>42</td>
<td>3 X 15</td>
<td>73</td>
<td>6 X 13</td>
<td>104</td>
<td>10 X 14</td>
</tr>
<tr>
<td>12</td>
<td>1 X 12</td>
<td>43</td>
<td>4 A</td>
<td>74</td>
<td>6 X 14</td>
<td>105</td>
<td>10 X 15</td>
</tr>
<tr>
<td>13</td>
<td>1 X 13</td>
<td>44</td>
<td>4 X 5</td>
<td>75</td>
<td>6 X 15</td>
<td>106</td>
<td>11 A</td>
</tr>
<tr>
<td>14</td>
<td>1 X 14</td>
<td>45</td>
<td>4 X 6</td>
<td>76</td>
<td>7 A</td>
<td>107</td>
<td>11 X 12</td>
</tr>
<tr>
<td>15</td>
<td>1 X 15</td>
<td>46</td>
<td>4 X 7</td>
<td>77</td>
<td>7 X 8</td>
<td>108</td>
<td>11 X 13</td>
</tr>
<tr>
<td>16</td>
<td>2 A</td>
<td>47</td>
<td>4 X 8</td>
<td>78</td>
<td>7 X 9</td>
<td>109</td>
<td>11 X 14</td>
</tr>
<tr>
<td>17</td>
<td>2 X 3</td>
<td>48</td>
<td>4 X 9</td>
<td>79</td>
<td>7 X 10</td>
<td>110</td>
<td>11 X 15</td>
</tr>
<tr>
<td>18</td>
<td>2 X 4</td>
<td>49</td>
<td>4 X 10</td>
<td>80</td>
<td>7 X 11</td>
<td>111</td>
<td>12 A</td>
</tr>
<tr>
<td>19</td>
<td>2 X 5</td>
<td>50</td>
<td>4 X 11</td>
<td>81</td>
<td>7 X 12</td>
<td>112</td>
<td>12 X 13</td>
</tr>
<tr>
<td>20</td>
<td>2 X 6</td>
<td>51</td>
<td>4 X 12</td>
<td>82</td>
<td>7 X 13</td>
<td>113</td>
<td>12 X 14</td>
</tr>
<tr>
<td>21</td>
<td>2 X 7</td>
<td>52</td>
<td>4 X 13</td>
<td>83</td>
<td>7 X 14</td>
<td>114</td>
<td>12 X 15</td>
</tr>
<tr>
<td>22</td>
<td>2 X 8</td>
<td>53</td>
<td>4 X 14</td>
<td>84</td>
<td>7 X 15</td>
<td>115</td>
<td>13 A</td>
</tr>
<tr>
<td>23</td>
<td>2 X 9</td>
<td>54</td>
<td>4 X 15</td>
<td>85</td>
<td>8 A</td>
<td>116</td>
<td>13 X 14</td>
</tr>
<tr>
<td>24</td>
<td>2 X 10</td>
<td>55</td>
<td>5 A</td>
<td>86</td>
<td>8 X 9</td>
<td>117</td>
<td>13 X 15</td>
</tr>
<tr>
<td>25</td>
<td>2 X 11</td>
<td>56</td>
<td>5 X 6</td>
<td>87</td>
<td>8 X 10</td>
<td>118</td>
<td>14 A</td>
</tr>
<tr>
<td>26</td>
<td>2 X 12</td>
<td>57</td>
<td>5 X 7</td>
<td>88</td>
<td>8 X 11</td>
<td>119</td>
<td>14 X 15</td>
</tr>
<tr>
<td>27</td>
<td>2 X 13</td>
<td>58</td>
<td>5 X 8</td>
<td>89</td>
<td>8 X 12</td>
<td>120</td>
<td>15 A</td>
</tr>
<tr>
<td>28</td>
<td>2 X 14</td>
<td>59</td>
<td>5 X 9</td>
<td>90</td>
<td>8 X 13</td>
<td>121</td>
<td>Bisi-2</td>
</tr>
<tr>
<td>29</td>
<td>2 X 15</td>
<td>60</td>
<td>5 X 10</td>
<td>91</td>
<td>8 X 14</td>
<td>122</td>
<td>Bisi-816</td>
</tr>
<tr>
<td>30</td>
<td>3 A</td>
<td>61</td>
<td>5 X 11</td>
<td>92</td>
<td>8 X 15</td>
<td>123</td>
<td>Bisi-18</td>
</tr>
<tr>
<td>31</td>
<td>3 X 4</td>
<td>62</td>
<td>5 X 12</td>
<td>93</td>
<td>9 A</td>
<td>124</td>
<td>Periwi-3</td>
</tr>
</tbody>
</table>
The genus *Jatropha* L. is belonging to Euphorbiaceae which it has a member about 175 species in the world. They are native species to Tropical America, Africa and some species found from South west Asia. In Thailand, some species of *Jatropha* were introduced more than 80 years for many purposes such as renewable energy plants, ornamental plants and medicinal plants. The objectives of this research are morphological study, species identification and distribution for all species are presented in Thailand. Specimens in herbarium were examined. Surveying and plants collecting were done from northern, north-eastern, central and southern. Result shown that the genus *Jatropha* in Thailand comprised with five species *viz.* *Jatropha curcas* L., *J. gossypiifolia* L., *J. integerrima* Jacq., *J. multifida* L. and *J. podagrica* Hook.f. Most of them are distribute throughout Thailand. Two species of *J. curcas* L. and *J. gossypiifolia* L. can be found in natural habitat. Three species of *J. integerrima* Jacq., *J. multifida* L. and *J. podagrica* Hook.f. can be found only in the garden by ornamental and medicinal purpose. The morphology of each species distinguished to recognize. User friendly key is constructed with full description, distribution and utilization.

Keywords: physic nut, bellyache bush, spicy jatropha, coral plant, *Jatropha* L.
ICCBES-1208
Roles of Calcium to Alleviate Manganese Toxicity in Sesame Seedlings (Sesamum Indicum L.)

Mohamed A. Adam\textsuperscript{a}, Kamrun Nahar\textsuperscript{a,b}, Jubayer-Al-Mahmud\textsuperscript{a,c}, Anisur Rahman\textsuperscript{a,d}, Md. Shahadat Hossain\textsuperscript{a}, Masayuki Fujita\textsuperscript{a*}

\textsuperscript{a} Laboratory of Plant Stress Responses, Department of Applied Biological Science, Faculty of Agriculture, Kagawa University, Japan

\textsuperscript{b} Department of Agricultural Botany, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh

\textsuperscript{c} Department of Agroforestry and Environmental Science, Sher-e-Bangla Agricultural University, Bangladesh

\textsuperscript{d} Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh

\textsuperscript{*} Corresponding author: fujita@ag.kagawa-u.ac.jp

1. Background/ Objectives and Goals
Manganese (Mn) is a naturally occurring element and an essential nutrient for plants. At higher concentration it causes toxicity in plants. Manganese toxicity is common in acidic soils. Calcium (Ca) uses the same transport channel as Mn and on the basis of this hypothesis, the present study was undertaken to study the roles of Ca in reducing Mn toxicity in sesame (Sesamum indicum L. cv. Kurogoma) plant.

2. Methods
Uniform and healthy seeds of sesame (Sesamum indicum L. cv. Kurogoma) were placed in dark germination chamber at 28°C for 72 hours. Germinated seedlings were grown under controlled conditions (light, 350 \textmu mol photon m\textsuperscript{-2} s\textsuperscript{-1}; temperature, 25±2°C; relative humidity, 65–70 %) in a growth chamber. Diluted (10, 000-fold) Hyponex solution (Hyponex, Japan) was applied as nutrient. Fourteen days old seedlings were pretreated with Ca (CaCl\textsubscript{2}, 2 and 5mM) for 24 hours. Calcium pretreated and non-pretreated fifteen days old seedlings were subjected Mn (MnCl\textsubscript{2}.4 H\textsubscript{2}O; 1 mM). Control plants were grown with Hyponex solution only. Treatments duration was 72 hours.

3. Results/ Conclusion/ Contribution
Manganese toxicity resulted in growth inhibition of sesame seedlings. Plant height, fresh weight and dry weight of seedlings significantly decreased due to Mn exposure. Manganese-induced oxidative damage was evident in sesame seedlings in terms of higher hydrogen peroxide (H\textsubscript{2}O\textsubscript{2}) and lipid peroxidation levels.
The contents of antioxidants, ascorbate (AsA) and glutathione (GSH) reduced under Mn stress. Disrupting osmotic balance, Mn reduced tissue water content. Calcium pretreatment had influential roles in alleviating toxic effects of Mn. Up regulating the antioxidant components (AsA and GSH), Ca reduced oxidative stress. Calcium regulated proline level to confer osmoprotection and to maintain tissue water content. Seedlings' growth performance was significantly improved by Ca pretreatment under Mn stress. Calcium is supposed to play roles in reducing Mn uptake which reduced the adverse effects of Mn in sesame plants.

Keywords: Abiotic stress, manganese toxicity, oxidative stress, sesame (Sesamum indicum L.), calcium
The present study was aimed to isolate and evaluate the diversity of \( \gamma \)-polyglutamate (\( \gamma \)-PGA) producing bacteria from rhizoplane of three Poaceae plants viz. rice (\emph{Oryza sativa} Linn.), maize (\emph{Zea mays} Linn.) and sugar cane (\emph{Saccharum officinarum} Linn.). The plant are cultivated and recognized as the most important agronomic crops of Thailand.

From the isolation, 368 isolates of rhizoplane bacteria were obtained from 18 root samples, 200 isolates from rice roots, 112 isolates from maize roots and 56 isolates from sugar cane roots. After subjected to the screening for \( \gamma \)-PGA producer, there were 186 isolates which exhibited \( \gamma \)-PGA producing ability, the concentration of \( \gamma \)-PGA obtained were ranging from 12.62 - 18.46 g/L based on tube culture experiment. From those 186 isolates there were 18 isolate which capable to produce \( \gamma \)-PGA higher than 15 g/L, thus the isolates were selected as the most efficient \( \gamma \)-PGA producers for further molecular characterization. The molecular genetic study based on 16s rDNA genes analysis revealed the selected \( \gamma \)-PGA producing isolates were closely related to strains of \emph{Bacillus subtilis} or of \emph{Bacillus amyloliquefaciens}, which are closely relate to the industrial strain of \( \gamma \)-PGA producing bacteria.

The study indicated that the rhizoplane of Poaceae plants and probably of other plant families should be an important reservoir of natural isolates of \( \gamma \)-PGA producing bacteria.

Keywords: Poly-\( \gamma \)-glutamic acid (\( \gamma \)-PGA), rhizoplane, Poaceae plants
1. Background and Objectives
Starch microsphere is a micron-sized spherical particulate prepared by destruction of native starch granules into starch dispersion state and subsequently reformed to spherical microparticle under controlled conditions. The starting material is important and can affect the properties of microsphere. Therefore, the objective of this study is to elucidate the effect of degree of starch hydrolysis on morphology and swelling property of the cassava starch microsphere. The hydrolyzed starches with different degrees of hydrolysis were prepared by acid hydrolysis at different time intervals and then used for microspheres formation.

2. Methods
Cassava starch was hydrolyzed with 2.2 N HCl for 6, 12, 24, 36 and 48 h. Molecular size and viscosity of hydrolyzed starches were investigated. The hydrolyzed starches were then used for microspheres formation using a water-in-water emulsion-crosslinking technique at 30°C for 12 h. The microspheres were analyzed for morphology and swelling power.

3. Results and Conclusion
Results from size exclusion chromatography revealed that the size of starch molecules decreased with increasing time of hydrolysis, especially the initial 6-24 h of hydrolysis. However, change in the size of starch molecules was not clearly observed when hydrolysis time was extended to 36 and 48 h. Viscosities of hydrolyzed starch gel (15 % w/v) at 30 °C
decreased as the hydrolysis time increased up to 24 h, after that the viscosities increased slightly. Scanning electron microscopy images of particles formed from the starch hydrolyzed for 6-12 h show that most of the particles had irregular shape and aggregated into small lumps. Separated particles with spherical shape and uniform size were found when the starch hydrolyzed for 24 h was used as a starting material. Microparticles prepared from the starch hydrolyzed for 36-48 h also displayed rounded shape, but there was more variation in size. Swelling power of all microsphere samples at 30-90°C ranged between 6.5-9.0 g/g sample. Microspheres prepared from starch hydrolyzed for 24 h had the lowest swelling power. Further increase in hydrolysis time to 36 and 48 h resulted in the microspheres with higher swelling power.

Keywords: acid-hydrolyzed starch, cassava starch, starch microsphere, morphology
ICCBES-1219

MicroRNA-1301-mediated RanGAP1 Downregulation Induces BCR-ABL Nuclear Entrapment to Enhance Imatinib Cytotoxicity in Chronic Myeloid Leukemia Cells

Yu-Chun Chan, Hsin-Yi Chou, Chunmin Liu
Chemical Engineering Department, Feng Chia University, Taiwan

Alex C.-C. Chang b,*
Chemical Engineering Department, Feng Chia University, Taiwan
b Green Energy Development Center, Feng Chia University, Taiwan
E-mail address: acchang@fcu.edu.tw

1. Background/ Objectives and Goals
Fossil fuel is still today’s major energy resource and causes global atmospheric pollution problems during its usage. Seeking for the alternative energy resource is the key issue for current energy research. Bioenergy production from non-food related feed stock by the thermal-chemical or the biological processes can be a good route for the alternative energy production. An integration process for acetone-butanol-ethanol (ABE) fermentation by the corn-cob hydrolyzate was proposed in this study.

2. Methods
The corn-cob hydrolystae was prepared by the biological process, hydrolyzed by T. reesei ATCC 26921(SIGMA), or the thermal chemical process, diluted acid catalyzed hydrolysis at 150°C following the over-lime treatment to remove the potential inhibitors. Clostridium acetobutylicum ATCC824 was used as the micro-flora for the acetone-butanol-ethanol fermentation process at 37°C, and the total sugar concentration of 70, 60, and 50 g/L and pH = 6.5, 6.0, and 5.5, respectively. The fermentation was originally studied in the batch mode. Further studied was focused in the CSTR operation.

3. Expected Results/ Conclusion/ Contribution
The results of experimental optimization showed the highest acetone, butanol, and ethanol concentration of 34.43, 3.89, and 0.29 g/L, respectively, by using 7.5% (w/v) corncob biomass hydrolyzate and modified P2 medium for fermentation. The developed process is easy in operation, simple and does not involve separate hydrolysis with acid and enzyme, and fermentation for production of butanol from lignocellulosic biomass. Our results demonstrate the feasibility of one pot process for butanol production from lignocellulosic biomass.

Furthermore, a continuous flow stirred tank reactor (CSTR) was used to explore the effects of
HRT (12 and 24 hours), pH (5.5 and 6.0) and different types of hydrolysate (enzymatic hydrolysate and dilute acid hydrolysate) on ABE production. The results showed that the optimal ABE yield and ABE production rate was $0.12 \pm 0.02$ mol/mol TSused and $1.84 \pm 0.35$ g/L/d, respectively, when the CSTR reactor was operated at pH 5.5, total sugar concentration 60 g/L and HRT 24 h with enzymatic hydrolysate.

Keywords: Simultaneous saccharification and fermentation, continuous flow stirred tank reactor, acetone-butanol-ethanol fermentation
The Functional Properties and Chemopreventive Analysis of Vernonia Amygdalina Extracts

Ker Sin Sim  
Department of Biotechnology and Animal Science, National Ilan University, Taiwan  
sks_910626@hotmail.com

Yen-Ting Lai  
Department of Biotechnology and Animal Science, National Ilan University, Taiwan  
F33562002@yahoo.com.tw

Shu-Rong Hsu  
Department of Biotechnology and Animal Science, National Ilan University, Taiwan  
lucy53255325@gmail.com

Yi-Chuan Lee  
Department of Biotechnology and Animal Science, National Ilan University, Taiwan  
yclee@niu.edu.tw

Hui-Chen Hsu*  
Department of Biotechnology and Animal Science, National Ilan University, Taiwan  
hchsu@niu.edu.tw

Background/ Objectives and Goals
Lung cancer remains one of the deadly cancers in the world and exhibits highly resistance to conventional treatment. Recently, studies show that fruits, plants and medical herbs could become potential chemopreventive agents to inhibit progression of cancer. Vernonia amygdalina (VA), a perennial shrub belongs to Asteraceae family, widely used as treatment for diabetes, gastrointestinal tract problems, liver disease and also as a potent inhibitor of human breast cancer cell MCF-7. In this study, we demonstrated the chemopreventive properties of VA extracts to human lung cancer cell A549.

Methods
VA dry/fresh leaves were grinded into powder and mixed with methanol. The mixture was then dried by rotary evaporators and dissolved with DMSO. Meanwhile, VA dry/fresh leaves were boiled with distilled water, resulting solution was lyophilized and diluted with distilled water. NO is produced by macrophages in response to inflammatory. In this case, NO assay is used to evaluate the anti-inflammatory effect of four VA extracts in Raw264.7. To determine the
cytotoxicity of VA extracts to A549 lung cancer cell, cell viabilities were measured by MTT assay. After that, expression of BCL-XL is observed after VA treatment (IC\textsubscript{50} and IC\textsubscript{75}) for 12, 24 and 72 hours using western blot. A549 cell morphologies after VA treatment were observed by confocal microscopy. Wound healing assay is used to study the VA extract effect to cell migration, a wound gap in cell layer is created by 200 μl tip and photos were taken after 12 and 24 hours.

**Expected Results/ Conclusion/ Contribution**

In NO assay, both VA extracts (dry leaves-methanol, dry leaves-water, fresh leaves-methanol and fresh leaves-water extract) exhibited anti-inflammatory activity to Raw 264.7 after LPS stimulation. After VA extracts treatment for 72 hour, VA dry leaves-methanol extract showing higher cytotoxicity (IC\textsubscript{50} = 47.77 μg/ml) against human lung cancer cell A549 compared to dry leaves-water, fresh leaves-methanol and fresh leaves-water extract (IC\textsubscript{50} = 203.42, 123.28, 586.57 μg/ml, respectively). In addition, we found that the expression of BCL-XL, an anti-apoptotic member of the Bcl-2 family, had declined after VA dry leaves-methanol treatment. Meanwhile, we also observed cell shrinkage in A549 cell line using confocal microscopy, revealed VA dry leaves-methanol extract cause apoptosis in A549. In wound healing assay, VA dry leaves-methanol extract inhibits cell migration of A549 in concentration IC\textsubscript{10} and IC\textsubscript{25}. Our study demonstrates the potential applications of VA as chemopreventive agent for lung cancer.

Keywords: *Vernonia amygdalina*, chemoprevention, inflammatory, apoptosis, cell migration
ICCBES-1258
EGFR-Targeted Micelles Containing Photosensitizers for Imaging and Photothermal Therapy of Colorectal Cancer

Ming-Jium Shieh*, Ping-Fang Chiang
Institute of Biomedical Engineering, College of Medicine and College of Engineering, National Taiwan University, Taiwan
E-mail address: soloman@ntu.edu.tw

Tsai-Yueh Luo,
Isotope Application Division, Institute of Nuclear Energy Research, Taiwan
E-mail address: clpeng@iner.gov.tw

Ying-Hsia Shihb, Wuu-Jyh Linb, Cheng-Liang Pengb,*
Institute of Biomedical Engineering, College of Medicine and College of Engineering, National Taiwan University, Taiwan
b Isotope Application Division, Institute of Nuclear Energy Research, Taiwan
E-mail address: clpeng@iner.gov.tw

Abstract
Purpose of this research was to investigate the effectiveness of EGFR-targeted micelles which loaded IR-780 (Cetuximab/IR-780 micelles) for multimodal images, tumor targeting, and photothermal therapy (PTT). First, we studied cellular uptake on HCT-116, HT-29 and SW-620 cell lines. HCT-116 tumors (EGFR over-expression) and SW-620 tumors (EGFR low-expression) were used to investigate in vivo bio-distribution and antitumor effect studies. Results of SPECT/CT imaging and bio-distribution of 111In-Cetuximab/IR-780 micelles showed highest accumulation on HCT-116 tumors, compared with SW-620 tumors (P<0.05). Time-lapse near-IR fluorescence (NIRF) images also indicated that IR-780 of Cetuximab/IR-780 micelles had highest accumulation on HCT-116 tumors (P<0.05). In antitumor effect studies, all HCT-116 bearing mice tumor were cured (P<0.05) at day 6 after injection of Cetuximab/IR-780 micelles with laser irradiation. However, the SW-620 tumors were relapsed at day 13 after PTT. In summary, we suggested that Cetuximab/IR-780 micelles with PTT could enhance the antitumor effect on colorectal cancer with high expression of EGFR.

Keyword(s): Cetuximab, IR-780, targeting, photothermal therapy.
Interaction between NS1 and Cellular MAVS Contributes to NS1 Mitochondria Targeting

Masaki Mibayashi a, Randy A. Albrecht a, Yeu-Yang Tseng b, Peter Palese a,b, and Wei-Li Hsu b*

a Department of Microbiology, Mount Sinai School of Medicine, USA
b Graduate Institute of Microbiology and Public Health, National Chung Hsing University, Taiwan
c Department of Medicine, Mount Sinai School of Medicine, USA

1. Background/ Objectives and Goals
Influenza A virus (IAV) nonstructural protein 1 (NS1) plays an important part in evading host innate immunity. It inactivates interferon (IFN) response via multiple mechanisms that includes sequestering dsRNA, the IFN trigger, and suppression of RIG-I signal transducing activity by interacting with RIG-I and TRIM 25. NS1 harbors both nucleus localization signals and a nuclear export signal which influence the dynamic intracellular localization of NS1.

2. Methods
To study the dynamic cellular distribution of IAV NS1, immunofluorescence and immunoblotting assays were employed to monitor the expression of NS1 in the course of IAV infection. In addition, molecular interaction was determined by standard co-immunoprecipitation method.

3. Expected Results/ Conclusion/ Contribution
In current study, the novel mitochondria localization of NS1 at early stage of infection was revealed for the first time. Since NS1 does not contain mitochondria targeting signal, we suspected and further proved the potential interaction of NS1 with mitochondrial antiviral-signaling protein (MAVS) and that is independent from RIG-I association. The MAVS interaction facilitates directing NS1 to mitochondria, and presence of NS1 significantly impedes IFN stimulation mediated by MAVS.

Keywords: Influenza virus, NS1, MAVS, mitochondria
ICCBES-1273
Fractionation of Bioactive Components from Ganoderma Amboinense Using Supercritical Carbon Dioxide Technology

Kuan-Wei Cheng
Department of Food Science, National Chiayi University, Taiwan, R.O.C.
E-mail address: foodscience66@gmail.com

Shu-Mei Lin
Department of Food Science, National Chiayi University, Taiwan, R.O.C.
E-mail address: smlin00@mail.nctu.edu.tw

Be-Jen Wang
Department of Food Science, National Chiayi University, Taiwan, R.O.C.
E-mail address: bejen@mail.nctu.edu.tw

Zer-Ran Yu
Superwell Biotechnology Corporation, Taichung City, Taiwan, R.O.C.
E-mail address: zerranyu@gmail.com

1. Background/ Objectives and Goals
Ganoderma amboinense contains various bioactive components, including polysaccharides, triterpenoids-ganoderic acid, polyphenolic compounds, and nucleosides. However, low concentrations of bioactive components in extract may limit their physiological activities and applications. The objectives of this study were to investigate the optimal operation process for yielding bioactive components-rich fractions from G. amboinense extract using supercritical carbon dioxide (SC-CO₂) fractionation technique as well as antioxidant activity of obtained fractions.

2. Methods
The G. amboinense was purchased from Yen Ten Farm, Chiayi, Taiwan. Dried G. amboinense powder was mixed with 85% ethanol at a ratio of 1:5 (w/v) for 72 h to yield ethanol extract (E). SC-CO₂ fractionation was performed using an orthogonal design to obtain optimal fractionation parameters. The operation conditions were: three different temperatures (40, 50, and 60°C), three different pressure levels (20, 30, and 40 MPa), three flow rates of Ganoderma extract liquor (1, 2, and 3 mL/min), and SC-CO₂ flow rate at 5 ml/min. Two separation vessels in series at pressures of 15 and 20 MPa were used to yield fraction (F) and residue (R) (material insoluble in SC-CO₂). The collected samples were then freeze-dried and the contents of various bioactive components and antioxidant activity of E, F and R were analyzed.
The levels of triterpenoids, polysaccharides, polyphenolic, and flavonoids were measured spectrophotometrically. Ganoderic acid A and adenosine were detected by high performance liquid chromatography (HPLC). The antioxidant activity was determined by DPPH radicals scavenging assay spectrophotometrically.

The optimal operation condition of SC-CO$_2$ fractionation was determined for (1) the high yield of active compounds indicated by the total contents of active components in both F and R fractions and (2) the selectivity ($F_{contents}$ of the active compounds/$R_{contents}$ of the active compounds) indicated by the great deviation deviated from 1.

3. Expected Results/Conclusion/Contribution

Our research group had successfully obtained many active components-rich fractions from various natural sources using SC-CO$_2$ fractionation technology and confirmed the bioactivity of obtained fractions in vitro or in vivo. The current study was extended from our previous studies to obtain active components-rich fractions of the alcohol extract of *G. amboinens* by SC-CO$_2$ fractionation.

The results showed that much higher level of the bioactive compounds, including total triterpenoids, total flavonoids, polyphenols, ganoderic acid A, and adenosine, was detected in either the extract (F) or residue (R) fraction compared to those in alcohol extract (E) of *G. amboinens*. The highest concentrations of triterpenoids, polyphenols and flavonoids were obtained in the fraction (F) at the operation condition of 20MPa, 50$^\circ$C and 3 ml/min sample flow rate; while the highest concentrations of ganoderic acid were yielded in the fraction (R) at the operation condition of 30MPa, 40$^\circ$C and 2 ml/min sample flow rate. The order of decreasing triterpenoids content (mg oleanolic acid/g dw) were F (348.34), E (105.79), and R (103.27); total polysaccharides content (mg glucose equivalent/g dw) were R (201.82), E (190.32), and F (154.13); polyphenols contents (mg GAE/g dw) were F (41.06), R (31.98), and E (20.15) and total flavonoids (mg/g dw) were F (59.92), E (41.25), and R (31.20). The order of decreasing ganoderic acid A content (mg/g dw) were R (83.17), E (22.37), and R (1.23).

The selectivity for adenosine was below 0.1 for all SC-CO$_2$ fractionation conditions tested in this study, indicating high partition efficacy for adenosine by SC-CO$_2$ fractionation. SC-CO$_2$ fractionation under 40MPa, 60$^\circ$C and 1 ml/min efficiently separated adenosine (high level in R part), from the other bioactive components in F part. The adenosine content in R, E, and F were 50.65, 33.28 and 2.27 mg/g, respectively. Furthermore DPPH radicals scavenging activity was increased in SC-CO$_2$ fractions. There is high correlation between antioxidant activity and total triterpenoids contents (P < 0.01). The correlation coefficient was 0.79 for DPPH radicals scavenging activity. In conclusion, this study showed that fractionation of *G. amboinense* extract using continuous SC-CO$_2$ technology was able to effectively concentrate bioactive
constituents in parallel with the increase in bioactivity.

Keywords: *Ganoderma amboinense*, supercritical carbon dioxide fractionation, bioactive components, antioxidant activities
1. Background

Macroautophagy (hereafter referred to as autophagy) is a key homeostatic mechanism for the turnover of such intracellular components as proteins/organelles, and is further related to various physiopathological conditions of the eukaryotic cell. The aim of this study is to propose a new integrative approach to the quantitative analysis of the autophagy pathway.

2. Methods

We develop a 'minimal autophagy model' which assumes a three-compartment description of the process, i.e., autophagosome, autolysosome, and protein/organelle compartments. The interactions among these compartments and the rates at which the concentrations of autophagosomes, autolysosomes, and protein/organelles vary with time are expressed mathematically. Then two quantitative indices measuring autophagy activities in the induction of sequestration fluxes and in the selective degradation are defined, based on the model.

3. Results and Perspectives

Via the computer simulations, we reconstruct key profiles of the autophagic process such as the time evolution of autophagy fluxes, levels of autophagosomes/autolysosomes, and corresponding cellular changes at good time resolution, from the biological experiments of the target autophagy system. Then, the target autophagy system is interpreted with the help of the quantitative autophagy not only to examine how the autophagy system responds to cellular damaging but also to prove the causal relationships among the steady-state autophagy levels, autophagic fluxes, and corresponding cellular changes in a specific and quantitative manner.

To develop such integrative approaches to the quantitative analysis of the autophagy pathway, based on the mathematical modeling and the simulation-based analysis, is highly challenging but indispensable for the assessment of the autophagy activity and of its roles associated with
different physiopathological states of human diseases.

Keywords: autophagy pathway, biophysical modeling, computer simulations, quantitative autophagy index
ICCBES-1377
Antibacterial Actions of Scleractinian Corals Extracts

Pornpimon Kanjanavas *, Pornnapa Phalawong, Chalitta Pumruang
Division of Biological Science, Faculty of Science and Technology,
Huachiew Chalermprakiet University, Thailand
kanjanavas@hotmail.com

Prasan Sangpiboon
Department of Biology, Faculty of Science and Technology,
Rambhai Barni Rajabhat University, Thailand

Abstract
This research studied antibacterial activity of extracts from four types of scleractinian corals; Ring coral (Favias peciosa), Staghorn coral (Acropora formosa), Foliose (Pavona decussate) and Staghorn coral (Acropora millepora) were supported from Marine Science Activity and Conservation Foundation (MACF), Chonburi province. Corals were extracted with methanol, ethyl acetate and hexane by using Maceration method, and then tested on its action with Agar disc diffusion, Minimum Inhibitory Concentration (MIC) and Minimum Bactericidal Concentration (MBC), respectively. The results showed the highest of clear zone received extracts from Favias peciosa in methanol as solvent gave 33.40±0.72 mm. for inhibition of Staphylococcus aureus and the extracts from Acropora formosa in ethyl acetate showed inhibition of Salmonella Typhimurium (15.87±1.52 mm.). In addition, the study of MIC and MBC on pathogenic bacteria showed the extracts from Acropora millepora in ethyl acetate had a highest inhibitory effect on Vibrio paraheamolyticus which had the MIC and MBC values equally were 0.98 µg/ml and 3.9 µg/ml concentration, respectively.
Keyword: Scleractinian extracts, stony coral extracts, Agar disc diffusion, Minimum Inhibitory Concentration, Minimum Bactericidal Concentration

1. Introduction
Antibiotic-resistant infection can happen anywhere. Each year, people were die because of infected with bacteria that are resistant to antibiotics. The antibiotic-resistant bacterium has stimulated the search for potent antibacterial agents from natural sources. Some reports show that more than 15,000 marine natural products have been isolated in the period from 1965 to 2005 (Blunt et al., 2007). Medicinal marine organisms are interesting for pharmacological research and drug development, since their constituents can be used for therapeutic agents and models for synthesis of drugs of pharmacologically active compounds. Novel biologically active compounds from natural marine organisms have been made to new therapeutic drugs against cancer (Radhika et al., 2005). The important compounds from marine organisms are
play important role for drugs production are secondary metabolites. Secondary metabolites produced in coral could be the source of bioactive substances and useful in modeling compounds for drugs (Bhosale et al., 1999). The pressure from the natural selection has led corals to develop a delicate chemical balance for self protection and the coral mucus layer serves as an ecological niche rich in nutrients and diverse in bacterial populations cause coral’s defense mechanism (Rohwer et al. 2002). Many reports showed soft corals are a rich source of steroids and terpenoids (Ruggieri, 1976; Faulkner, 2002), and most isolated diterpenes are cembranolides (Faulkner, 2001). On the other hands, scleractinian corals are the majority in coral reefs, but their chemical defenses have been comparatively less studied. Such as reported by Ritchie (2006) found bacteria from the mucus layer of the coral *Acropora palmaine* displayed antimicrobial activity, and that a novel mucus mediated medium was found to be selective for isolates that produce antibiotics. Scleractinian corals, which are known as “stony coral” because of their hard calcium carbonate skeletal structure (Sato et al., 2013). Many types of scleractinian corals such as Ring coral (*Favias peciosa*), Staghorn coral (*Acropora formosa*), Foliose (*Pavona decussate*) and Staghorn coral (*Acropora millepora*) are culture in Marine Science Activity and Conservation Foundation (MACF), Chonburi province, Thailand.

Coral reefs are advantages for numerous organisms but warming of the ocean and human activity causes corals to sicken and die. In this study, we screened for the antibacterial activity of the crude extracts of *Favias peciosa, Acropora formosa, Pavona decussate* and *Acropora millepora* against to pathogenic bacteria for discovering their advantage and may lead to corals conservation.

2. Methods

**Bacterial Strains**

*Vibrio parahaemolyticus, Escherichia coli, Staphylococcus aureus, Bacillus cereus, Salmonella Typhimurium* and *Pseudomonas aeruginosa* were obtained from Division of Biological Science, Faculty of Science and Technology, Huachiew Chalermprakiet University. Cultivation of all bacteria was performed using nutrient agar with incubation at 37 °C for 24 h. excepted *V. parahaemolyticus*. *V. parahaemolyticus* was cultured on nutrient agar with 3% NaCl and incubation at 37 °C for 24 h.

**Collection of Coral Samples**

The four stony corals cultured such as *Favias peciosa, Acropora formosa, Pavona decussate* and *Acropora millepora* were collected using scuba diving along the coast of Eastern Thailand. Branch tips of each species was cut into small pieces about 5-8 cm in length then were collected in sterile plastic bags containing surrounding sea water and maintained at -20 °C until extraction. Information on the organism, the place of collection, date of collection and depth
were recorded. Coral species identification was carried out by Marine Science Activity and Conservation Foundation (MACF).

**Extraction of Coral**
The wet weight of the coral and its volume were measured. Samples were extracted by maceration technique with methanol, ethyl acetate and hexane, respectively. The 100 g of coral washed with 70% ethanol and artificial seawater for two times before smashed with mortar then soaked in 200 ml methanol at 25 °C. After one week, extracts were filtered through the filter (Whatman No.4) and the filtrates were collected. The same extraction and filtration steps were repeated two times by using ethyl acetate and hexane solvent, respectively. Filtrates were evaporated and dried utilizing rotary vacuum evaporator at 60 °C. Coral extracts were dissolved at a concentration of 0.5 mg/ml in 30% dimethyl sulfoxide (DMSO) at the stock solution.

**Antimicrobial Assays**
A disc diffusion assay was performed on pathogenic bacteria. Before the bioassay, each bacterium was cultivated in nutrient broth except *V. parahaemolyticus* was cultured in nutrient broth mixed with 3% NaCl until an optical density of 0.8-0.1(OD$_{600}$). Inoculate of cultures (approximately $10^8$ cell/ml) of each bacterial strain were swabbed onto the surface of Mueller Hinton Agar plates. The coral extracts of each stock solution (10 µl) were pipette onto a 6 mm. sterile paper disc, the solvent was allowed to evaporate, and the disc was placed on the surface of the inoculated agar. Agar plates were incubated hr at 37 °C for 24 h. and inhibition zone formed were measured and compared with ampicillin antibiotics test. For all samples were performed in triplicates. The crude stony coral extracts which showed a presence of antimicrobial activities against the bacterial strain tested were subjected to broth microdilution and colorimetric assay to evaluate their respective minimum inhibition concentration (MIC) and minimum bactericidal concentration (MBC) values.

Minimum inhibitory concentration (MIC) was measured by determining the smallest amount of extract or pure compound needed to inhibit the growth of a test bacterium. MIC was performed in 96-well plates. Each well of 96-well microtiter plate was a liquoted with 100 µl of bacteria cultured in Mueller-Hinton broth (MHB), excepted *V. parahaemolyticus* was cultured in MHB with 3% NaCl ; 11th well (positive control) was added MHB with 200 µg/ml of ampicillin, 12th well (negative control) was added with MHB and 30% DMSO. 100 µl of the crude stony coral extracts initially dissolved in 30% DMSO to the concentration of 500 µg/ml was added to the first well. Then, a serial two-fold dilution was performed by transferring 100 µl of the suspension to the subsequent wells up till the 10th well; the final 100 µl of the suspension was discarded broth. Finally, 5 µl of resazurin solution, as an indicator of microbial growth, was added to each well. The inoculated plates were incubated at 37 °C for 24 h. MIC was defined
as the lowest concentration of tested compound that prevented resazurin color change from blue to pink. MBC was determined by plating 10 µl of samples from wells, where no indicator color change was recorded, on nutrient agar. At the end of the incubation period, the lowest concentration with no growth (no colony) was defined as minimum bactericidal concentration. The test was performed in triplicates. Ampicillin, dissolved in a nutrient liquid medium was used as a positive control. A solvent control test was performed to study an effect of 30% DMSO on the growth of bacteria. It was observed that 30% DMSO did not inhibit the growth of bacteria. All test was performed in triplicates and MICs were constant.

3. Results and Discussion

Stony coral oral extraction
Coral samples were extracted by maceration technique with methanol, ethyl acetate, and hexane, respectively. After extraction, the organic extract shows different in color and feature as shown in table 1.

Antimicrobial Activity
Agar disc diffusion assays were performed with extracts of four stony corals against the six pathogenic bacteria is presented in table 2. The solvent (30% DMSO) had no effect on the growth of tested bacteria and the extracts from hexane as a solvent had no effect on pathogenic bacteria too. The data revealed the compound agent that dissolved in hexane had no effect to pathogenic bacteria according to Sato (2013) reported extracts of Acropora pulchra tissue had antibacterial activity was found in a hydrophilic fraction. Antimicrobial activity was found mostly among extracts obtained with non-polar rather than the hydrophilic solvents (Miroslav et al., 2011; Kreitlow, 1999). The crude extracts from ethyl acetate and methanol inhibited the growth of S. aureus, S. Typhimurium, B. cereus and P. aeruginosa except E. coli and V. parahaemolyticus. The largest inhibition zones were observed for the antibiotic control and the extracts from F. peciosa and A. millepora using methanol as a solvent could inhibit the growth of S. aureus (Table 2). The 0.5 mg/ml of crude extracts could not inhibit the growth of E. coli and V. parahaemolyticus by agar disc diffusion assay. The level activity that is measured in disc diffusion assay is dependent on both the rate of diffusion of the extract into the agar and potency of the extract. Extracts that contain highly active compounds, but have physical properties that generate a lower diffusion rate, may appear to have low activity in the assay (Kelman et al., 2006).
The problem can be overcome by performing MIC assays in liquid media, as shown in table 3. Antibacterial activity of stony coral extracts was evaluated by determining MICs and MBCs in relation to six species of Gram-positive and Gram-negative bacteria. The ethyl acetate extracts showed strong inhibition both Gram-positive and Gram-negative bacteria more than the methanol extracts. The methanol extracts presented inhibitory effects against Gram-negative than Gram-positive bacteria. The MIC values of ethyl acetate extracted from *A. millepora* were in the range from 0.98 µg/ml to 0.0078 mg/ml, while the MBC values were in the range from 3.9 µg/ml to 125 µg/ml. The results indicated that the most sensitive bacteria were *V. paraheamolyticus* (MIC at 0.98 µg/ml and MBC at 3.9 µg/ml). The ethyl acetate extracts of *A. formosa* showed inhibition both *P. aeruginosa* and *B. cereus* but ethyl acetate extracts of *P. decussate* could inhibit only *B. cereus*. The results indicated at low concentration of extracts could inhibit pathogenic bacteria according to the methanolic and ethyl acetate extracts from *Porites compressa* and *Platygyra daedatea* had antibacterial activity against *S. aureus* in range 4-15 µg/ml. antibacterial activity (Mohammadizadeh *et al.*, 2014).

<table>
<thead>
<tr>
<th>Species of coral</th>
<th>solvent</th>
<th>Weight (g)</th>
<th>Feature</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Favia pacifica</em></td>
<td></td>
<td>23.52</td>
<td>Dark green and white crystal</td>
</tr>
<tr>
<td><em>Acropora forma</em></td>
<td></td>
<td>20.05</td>
<td>Dark green and white crystal</td>
</tr>
<tr>
<td><em>Favia decussa</em></td>
<td>Methanol</td>
<td>28.13</td>
<td>Dark green</td>
</tr>
<tr>
<td><em>Acropora mille</em></td>
<td></td>
<td>25.21</td>
<td>Dark green</td>
</tr>
<tr>
<td><em>Favia pacifica</em></td>
<td>Ethyl acet</td>
<td>3.18</td>
<td>Dark brown viscous oil</td>
</tr>
<tr>
<td><em>Acropora forma</em></td>
<td></td>
<td>4.13</td>
<td>Dark brown viscous oil</td>
</tr>
<tr>
<td><em>Favia decussa</em></td>
<td>Ethyl acet</td>
<td>22.37</td>
<td>Dark brown viscous oil</td>
</tr>
<tr>
<td><em>Acropora mille</em></td>
<td></td>
<td>4.27</td>
<td>Dark green and white crystal</td>
</tr>
<tr>
<td><em>Favia pacifica</em></td>
<td>Hexane</td>
<td>2.31</td>
<td>Orange viscous oil</td>
</tr>
<tr>
<td><em>Acropora forma</em></td>
<td></td>
<td>2.43</td>
<td>Orange viscous oil</td>
</tr>
<tr>
<td><em>Favia decussa</em></td>
<td>Hexane</td>
<td>3.86</td>
<td>Orange viscous oil</td>
</tr>
<tr>
<td><em>Acropora mille</em></td>
<td></td>
<td>2.32</td>
<td>Orange viscous oil</td>
</tr>
</tbody>
</table>
Table 2: Antibacterial activity of stony coral tissue extracts by agar disc diffusion method.

<table>
<thead>
<tr>
<th>Bacteria strain</th>
<th>Stony Coral species</th>
<th>Concentration 0.5 mg/ml</th>
<th>Negative control 30% DMSO (mm. ±SD)</th>
<th>Positive control Ampicillin 2μg/disc (mm. ±SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hexane (mm. ±SD)</td>
<td>Ethyl acetate (mm. ±SD)</td>
<td>Methanol (mm. ±SD)</td>
</tr>
<tr>
<td>E. coli</td>
<td>F. peciosa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>S. Typhimurium</td>
<td>F. peciosa</td>
<td>8.57±0.50</td>
<td>12.63±0.37</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>15.67±1.52</td>
<td>14.4±1.58</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>13.6±0.08</td>
<td>10.2±0.34</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>9.6±0.00</td>
<td>16.6±0.00</td>
<td>-</td>
</tr>
<tr>
<td>P. aeruginosa</td>
<td>F. peciosa</td>
<td>9.97±0.53</td>
<td>13.3±0.63</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>9.80±1.51</td>
<td>8.6±0.57</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>13.50±0.50</td>
<td>10.2±1.25</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>11.50±1.01</td>
<td>13.6±0.35</td>
<td>-</td>
</tr>
<tr>
<td>V. parahaemolyticus</td>
<td>F. peciosa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>S. aureus</td>
<td>F. peciosa</td>
<td>12.67±4.16</td>
<td>33.4±0.72</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>3.7±5.52</td>
<td>10.43±0.51</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>8.4±0.17</td>
<td>19.5±0.17</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>3.7±6.52</td>
<td>10.43±0.51</td>
<td>-</td>
</tr>
<tr>
<td>B. cereus</td>
<td>F. peciosa</td>
<td>3.43±5.94</td>
<td>10.20±0.72</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>11.23±0.92</td>
<td>9.50±2.16</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>11.26±2.19</td>
<td>10.10±0.17</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>P. decussata</td>
<td>10.43±0.51</td>
<td>10.46±0.15</td>
<td>-</td>
</tr>
</tbody>
</table>

- : No inhibition zone
Table 3 The Minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) values of stony coral tissue extracts

<table>
<thead>
<tr>
<th>Bacteria strain</th>
<th>Coral species</th>
<th>MIC Concentration = SD</th>
<th>MBC Concentration = SD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Hexane (µg/ml)</td>
<td>Ethyl acetate (µg/ml)</td>
</tr>
<tr>
<td><strong>E. coli</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td><strong>S. Typhimurium</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td><strong>P. aeruginosa</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>31.3±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td><strong>V. parahaemolyticus</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>9.9±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>31.3±0.0</td>
</tr>
<tr>
<td><strong>S. aureus</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>125±0.0</td>
</tr>
<tr>
<td><strong>B. cereus</strong></td>
<td>F. pectosa</td>
<td>-</td>
<td>250±0.0</td>
</tr>
<tr>
<td></td>
<td>A. formosa</td>
<td>-</td>
<td>63±0.0</td>
</tr>
<tr>
<td></td>
<td>A. millepora</td>
<td>-</td>
<td>7.8±0.0</td>
</tr>
<tr>
<td></td>
<td>P. docussata</td>
<td>-</td>
<td>31.3±0.0</td>
</tr>
</tbody>
</table>

- : No inhibition

4. References


Extraction and Characterization of Gelatin from Snakeskin Gourami
(Trichogaster Pectoralis) Scale

Chaunpis Jirapong*, Alisa Soontornwat, Pornpimon Kanjanavas,
Chairat Techavuthiporn
Division of Biological Science, Faculty of Science and Technology,
Huachiew Chalermprakiet University, Thailand
yang_dede@hotmail.com

Abstract
Gelatins was extracted from scale of Snakeskin gourami (Trichogaster pectoralis) fish by low alkaline extraction process. The aim of the study was to determine the optimal conditions for preparing gelatin from different sodium hydroxide concentrations. Results showed that the fish gelatins were slight yellow-white colour, translucent, light textured in appearance and least of fishy odour. The yield of gelatin extraction from 0.3% sodium hydroxide as possessed for 1 and 3 hours soaking time were 9.86% and 9.44%, respectively. However, in preliminary treatment were using 1% sodium hydroxide solution obtain most clearly liquid gel, higher setting temperature at 23 °C and minimum setting time in 13 seconds. That it mean easier incorporate and gel setting in food product.

Keywords: Snakeskin gourami, Fish gelatin, Fish scale, Extraction

1. Background
Gelatin is essential ingredients in the preparation of worldwide dessert. It’s a colorless, translucent and odorless substance that is made from the hydrolysis of collagen found inside animal bones and skin (mainly beef and pork) (Veis, 1964). Gelatin comes in the form of powder, granules or sheets, which can be dissolved in warm liquid (35°C) and left to set at low temperatures. But the exact gelling would depend upon the concentration and time of standing. The chemical composition and structural features of gelatin depend on the source of collagen, processing parameters (temperature, time, and pH) and the hydrolytic treatment (acid hydrolysis or alkaline hydrolysis) used. Gelatin, although comprises 98 to 99% protein, it is unusually high in the content of amino acids (proline and hydroxyproline). The high gel strength and melting point tends to have high levels of amino acids composition in gelatin (Johnston-Banks, 1990).

Fish gelatin is available used in non-mammalian gelatin for halal and kosher food. In recent year, food markets have revived the interest in gelatin from fish raw materials because of the raised concern and fear of bovine spongiform encephalopathy (BSE) or “mad cow disease”
Fish gelatin discards generally include skin, bones and scales from fish processing accounts for approximately 50-70% weight of raw material (Shahidi, 1994). The extraction of gelatin from fish waste by different methods has been done to improve the function properties of the fish gelatin.

Fish production was estimated at 3.385 million tones in fisheries industries of Thailand (Pongthana, 2001). Siamese gourami (Trichogaster pectoralis) is one of important fish species in water bodies of freshwater in many areas. Traditional dried Siamese gourami fish products widely consumption because it have high meat quality. But this processing have to out of fish scales, which had high of fish scales waste. So, the objective of this study was to extract gelatins from the scales of Siamese gourami, as well as to determine the optimal conditions for its extraction and to determine some characteristics of gelatin.

2. Material and Methods

2.1. Raw Material
The fish scale samples were collected from Samutprakan province farm in Thailand and kept at 4 °C during carried to Huachiew Chalermprakiet University’s laboratory. The samples were washed with clean water and packed in polyethylene plastic bags and stored at -20 °C until use.

2.2. Extraction of Gelatin
The conditions for producing gelatin form fish scales were started by soaking in 0.1, 0.2, 0.3, 0.4 and 0.5 percentage (w/v) of sodium hydroxide (NaOH) for 1, 3 and 5 hours, followed by washing out sodium hydroxide. After that soaking in 0.2% acetic acid solution for 3 hours. The acid solutions were drained and then samples were washed with water. The final extraction of gelatin was performed in distilled water at 80°C for 3 hours, followed by homogenized and filtrated. Then stirring in 1.0% activated carbon for 10 min. The gelatin was centrifuged at 12,000 rpm and all supernatant dried at 60°C for 24 hours.

2.3. Calculation of Gelatin Yield
The gelatin yield was calculated as follows

\[
yield \text{ of gelatin (\%)} = \frac{\text{amount of gelatin film (g)}}{\text{sum of fish scale (100 g fresh weight)}} \times 100
\]

2.4. Determination of Gelatin Turbidity
The turbidity was determined on 10% (w/v) gelatin solution. Measurement of turbidity with a spectrophotometer at 610 nm. and determine the percent transmittance (%T).

2.5. Determination of Setting Point and Setting Time
Setting point and setting time were determined on 10% (w/v) gelatin solutions dissolved samples from the warm water bath held at 40°C. Then transfer in ice bath, a thermometer was inserted into the sample. The temperature of the mixture at which the gelatin solution no longer dripped from the tip of the thermometer was recorded as the setting temperature. The time at which the thermometer could not detach from the gelatin sample was recorded as the setting time.

3. Results and Discussion
The scale of Snakeskin gourami fish can be a valuable source of gelatin. Table 1 shows the visual appearance of gelatin extracted from different conditions of Snakeskin gourami scale. All of gelatin had a slight yellow-white colour, translucent and light textured. Gelatin extracted from 0.1% sodium hydroxide possess appear non-smooth, it have some air bubble inside film. On the other hand, gelatin extracted from 0.5% sodium hydroxide possess shown light, thin and easily creak film. But all of treatment had the least fishy odour. The colour and odour of the gelatin depends on the raw material (Karim and Rajeev, 2009). However, these gelatins easier incorporate into any food product and does not influence other functional properties.

<table>
<thead>
<tr>
<th>Table 1: The visual appearance of gelatin extracted from different conditions of Snakeskin gourami scale</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Soaking time of NaOH</strong></td>
</tr>
<tr>
<td>----------------------------</td>
</tr>
<tr>
<td>1 hours</td>
</tr>
<tr>
<td>3 hours</td>
</tr>
<tr>
<td>5 hours</td>
</tr>
</tbody>
</table>
In the extraction process conducted in sodium hydroxide, the yield of gelatin extraction was 9.86% and 9.44% from fresh fish scale, which soaking in 0.3% sodium hydroxide were used as process at 1 and 3 hours, respectively (Fig 1). Whereas other conditions was found to produce the least gelatin extract, yielding about 4-8% of the total fish scale weight. The low percentage of gelatin recovery was obtained 0.1% sodium hydroxide in extraction possess. It lowest when soaking 1 hours, with 4.49% of the total fish scale weight. This lower yield may be due to condition of alkaline hydrolysis of extracted collagen, loss of collagen during washing steps or leaching steps. A yield of gelatin depending on the sodium hydroxide solution concentrations used in preliminary treatment (Montero and Gómez-Guillén, 2000; Gudmundsson and Hafsteinsson, 1997).

Functional properties of gelatin extracted show in table 2. The pH of the gelatin was indicated base, with 7.63 to 9.11. These pHs are slightly different between treatment. In result, turbidity of fish gelatin extracted from 0.1% sodium hydroxide possessed have most clearly liquid gel than another condition. It is well known that gelling point of gelatin has a much lower temperature. In this study, treatment of gelatin extracted from 0.1% sodium hydroxide possessed and 5 hours soaking had higher setting temperature at 23 °C and lower setting time in 13 seconds. This result may be due to the molecular weight distribution exhibited some functional properties of this gelatin (Yau, et al., 1979). However, the functional properties of gelatin not only depends on molecular weight distribution, as well as the amino acid composition (Johnston-Banks, 1990)
Table 2: Functional properties of gelatin extracted from different concentration of sodium hydroxide at various times

<table>
<thead>
<tr>
<th></th>
<th>Concentration of sodium hydroxide</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.1%</td>
</tr>
<tr>
<td>Setting temperature (°C)</td>
<td></td>
</tr>
<tr>
<td>1 hours</td>
<td>15±3.93</td>
</tr>
<tr>
<td>3 hours</td>
<td>19±3.18</td>
</tr>
<tr>
<td>5 hours</td>
<td>23±0.33</td>
</tr>
<tr>
<td>Setting time (s)</td>
<td></td>
</tr>
<tr>
<td>1 hours</td>
<td>28±1.20</td>
</tr>
<tr>
<td>3 hours</td>
<td>24±2.08</td>
</tr>
<tr>
<td>5 hours</td>
<td>13±1.45</td>
</tr>
<tr>
<td>pH of gel</td>
<td></td>
</tr>
<tr>
<td>1 hours</td>
<td>7.63±0.19</td>
</tr>
<tr>
<td>3 hours</td>
<td>7.83±0.01</td>
</tr>
<tr>
<td>5 hours</td>
<td>7.81±0.11</td>
</tr>
<tr>
<td>Turbidity (%T)</td>
<td></td>
</tr>
<tr>
<td>1 hours</td>
<td>82.71±2.57</td>
</tr>
<tr>
<td>3 hours</td>
<td>84.91±0.66</td>
</tr>
<tr>
<td>5 hours</td>
<td>89.06±1.91</td>
</tr>
</tbody>
</table>

Acknowledgements

The authors acknowledge with thanks the financial support received under research from Huachiew Chalermprakiet University

4. References


ICCBES-1383
In Vitro Gastric and Pancreatic Digestion of Anthocyanins Extracted from Mulberry Fruit

Alisa Soontornwat*, Chaunpis Jirapong, Pornpimon Kanjanavas
Division of Biological Science, Faculty of Science and Technology,
Huachiew Chalermprakiet University, Thailand
E-mail address: alis_peep@hotmail.com

Chalermchai Wongs-Aree
Postharvest Technology Program, School of Bioresources and Technology,
King Mongkut’s University of Technology Thonburi, Thailand

Abstract
Mulberry is a good dietary source of anthocyanins and its antioxidant properties with shown the nutraceuticals. Anthocyanins have been recognized to be a potential for preventing chronic degenerative diseases. However, changes of temperature and pH in human digestion may be affected on color and antioxidant activity degradation of consumed anthocyanin extracts. This study was to investigate anthocyanin content, total phenolic compounds and the antioxidant activity during in vitro model simulating gastrointestinal digestion of mulberry extract. Results showed that anthocyanin content was in steady level under gastric digestion, whereas total phenolic compounds slightly increased. Anthocyanin content and total phenolic compounds were degraded under a pancreatic condition. Changes in antioxidant activities during the digestion were correlated to the changes in total phenolic compounds as well as the anthocyanin content. This suggests that the anthocyanin and antioxidant activities are evaluated by pH changes and enzyme conditions, appearing in the digestive system.

Keywords: Mulberry fruit, in vitro digestion, anthocyanin, antioxidant

1. Background/ Objectives and Goals
Non-communicable diseases (NCDs), also known as chronic diseases are not passed from person to person. The 4 main types of NCDs are cardiovascular diseases, cancers, chronic respiratory diseases and diabetes causing more deaths worldwide than all other causes of death combined (WHO, 2015). Unhealthy diets, tobacco use, exposure to environmental carcinogens and physical inactivity are documented as the major causes of NCDs. The major factor are conduce the production of free radical group such as reactive oxygen and nitrogen species in biochemical reactions in human cells. These presence needs to be neutralized by antioxidants. Therefore it’s provide and repair a balanced oxidants-antioxidants in human system.
Polyphenol establish the majority of secondary plant metabolites and also of dietary antioxidants (Bouayed, 2010; Bouayed and Bohn, 2010). Anthocyanins represent an important group of phenolic compounds called flavonoids. They function as pigments in plants and are nutraceuticals with show the prevent disease through their biological activity that include antioxidant function (Betanzo et al., 2014). In Thailand, mulberry fruit widely consumed and is well known as a good source of anthocyanins. In previous studies, mulberry fruits have been reported to biological activities, such as antioxidant (Kim et al., 1999; Naderi et al., 2004), antimicrobial (Takasugi et al., 1979). In addition to studies effect of in vitro digestion on dietary polyphenols, e.g. flavonoid and phenolic compound in anthocyanins in raspberry (McDougall et al., 2005) However, there is no data about the change of anthocyanin and antioxidant of anthocyanin extract to in vitro gastric and pancreatic digestion. The objective of this research was to investigate stability of anthocyanin extract from mulberry and change antioxidant activity during digestion.

2. Methods
Mulberry fruit were harvested from orchards in Phatchabun province, Thailand. Mulberry were selected for uniformity of size and color purple-red; they were freeze dry and stored at -20 ºC. Samples of 50 g (dry weight) were mashed and sonicated for 3 hr. in 500 ml of methanol. The mixture was then filtered through a filter paper (Whatman No. 1). The solvent was then remove using a rotary evaporator (BÜCHI Rotavapor R-205, Japan). Anthocyanin extract from mulberry were stored at -20 ºC for further analysis. This extract was subjected to successive in vitro gastric and pancreatic digestion, following method of Ferruzzi et al., 2001. The gastric digestion, diluted of anthocyanin extract from mulberry (1:10, anthocyanin extract: NaCl) were adjusted to pH 2.0 with HCl and the mixture was incubated with of pepsin in a shaking bath at 37 ºC for 2 h. The end of the gastric digestion, the pH was brought to 6.5 with NaHCO₃ before adding pancreatic and bile salt. The solution was incubated at 37 ºC for 2 h. At different time of gastric and pancreatic digestion (0, 30, 60, 90, 120 min) aliquots of samples were removed for total anthocyanin total phenolic and antioxidant activity analysis. The experiment was performed in 5 replications.

2.1 Total anthocyanin was measured following Giusti and Wrolstad, 2005; Wongs-Aree et al, 2006 method. Absorbance was determined at 700 nm using a UV-visible spectrophotometer (Shimadzu, UV-1601, Japan). The total anthocyanin content was calculated using the equation:

\[
\text{Monomeric anthocyanin pigment (mg/liter)} = \frac{(A \times MW \times DF \times 1000)}{(\varepsilon \times 1)}
\]

Where:  
\(A = (A \lambda \text{ vis-max} - A 700)\)

\(DF = \text{dilution factor}\)

\(MW = \text{molecular weight and molar absorptivity (449.2)}\)

\(\varepsilon = \text{molar extinct coefficient of cyanidin-3-glucoside (26,900 L/mol/cm)}\)
2.2 Total phenolic content of digested fraction were estimated by the Folin-Ciocaiteau method (Singleton and Rossi, 1965). Absorbance was determined at 725 nm using a UV-visible spectrophotometer. Different concentration of gallic acid were used to generate a standard curve.

2.3 Antioxidants activity was determined by DPPH Radical Scavenging activity (method modifications from Thaipong et al., 2006) Ferric reducing antioxidant power assay (Benzie and Strain,1996) and ABTS radical scavenging activities (method modifications from Kriengsak et al., 2006)

3. Results

This experiment monitor the release of phytochemical (total phenolic and anthocyanin) from anthocyanin extract of mulberry fruit during digestion. Total anthocyanin content in different stage of digestion shown in Fig 1. The anthocyanin contents was in steady level in the gastric digestion, with 32.41-40.06 mg/ml, whereas total phenolic compounds slightly increase. Our Results, during gastric digestion was stability of anthocyanins under acidic conditions in agreement with those reported for raspberry (McDougall et al., 2005) or pomegranate (Pérez-Vicente et al., 2002) anthocyanins. Moreover, Perez-Vicente et al., 2002 reported a small increase in anthocyanins after in vitro stomach digestion. The effect of pH on the stability of anthocyanin which affects the stability of anthocyanin is the acidic solution. Flavylium salts are stable only in highly acidic conditions. These salts loose the proton in higher pH and transform into quinoidal base, which is an unstable pigment, and immediately bond to water and form colourless compound called chromenol (Bermúdez-Soto et al., 2007). The transition from the acidic gastric to the mild alkaline intestinal was found a dramatic drop in the amount of 9.96 mg/l of anthocyanin content, which was related to total phenolic compounds (Fig 1 and Fig 2). After this initial decline, the incubation with pancreatic solution observed a decrease in the bio-accessibility of anthocyanin whereas total phenolic compounds was slightly increased (Fig2). The high instability of anthocyanins at neutral or slightly basic pH has been observed in other studies (Bermúdez-Soto et al., 2007; McDougall et al., 2005a, 2005b; Pérez-Vicente et al., 2002). Stabilities of polyphenols under gastric conditions is accordance with early absorption from the stomach of intact anthocyanin.

In table 1 the changes in antioxidant activity, measured with both DPPH FRAP and ABTS assay, during the in vitro gastro-intestinal digestion are shown. As the FRAP assay was rise steadily in gastric digestion with different the DPPH and ABTS shown steady level. When the changes in antioxidant activity were measured with the FRAP assay we found a good correlation between the extraction of total polyphenols and the increase in antioxidant activity during gastric digestion. In fact, it is well known from the literature that the radical scavenger activity of polyphenols is strongly pH-dependent with higher pH values which significantly
increase this capacity. This increase in the radical scavenger activity has been attributed to the deprotonation of the hydroxyl moieties present on the aromatic rings of the phenolic compounds (Mukai, Oka, Watanabe, Egawa, & Nagaoka, 1997; Tyrakowska et al., 1999).

After this initial decline, the incubation with pancreatic solution observed a sharply decrease in antioxidant activity of DPPH and FRAP assay. In pancreatic digestion, the antioxidant activity was reduce with associate total phenolic compound. The polyphenols with the highest antioxidant activity at acidic pH are not necessarily those with the highest antioxidant activity at the mild alkaline pH value. This suggests that the anthocyanin and antioxidant activities are evaluated by pH changes and enzyme conditions, appearing in the digestive system.

Fig. 1: Change in the amount of anthocyanin extracted during the gastro-intestinal simulated digestion

Fig. 2: Change in the amount of total phenolic compound during the gastro-intestinal simulated digestion
Table 1: Antioxidant activity of anthocyanins extracted from mulberry fruit individually subjected to simulated gastric-intestinal digestion.

<table>
<thead>
<tr>
<th></th>
<th>Antioxidant activity</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>DPPH assay</td>
<td>FRAP assay</td>
<td>ABTS assay</td>
</tr>
<tr>
<td>Gastric digestion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 min</td>
<td>0.49±0.045</td>
<td>6.84±1.238</td>
<td>1.12±0.001</td>
</tr>
<tr>
<td>30 min</td>
<td>0.60±0.027</td>
<td>5.87±0.558</td>
<td>1.12±0.004</td>
</tr>
<tr>
<td>60 min</td>
<td>0.55±0.025</td>
<td>8.13±1.506</td>
<td>1.10±0.012</td>
</tr>
<tr>
<td>90 min</td>
<td>0.58±0.041</td>
<td>8.11±1.723</td>
<td>1.12±0.001</td>
</tr>
<tr>
<td>120 min</td>
<td>0.54±0.064</td>
<td>10.80±1.597</td>
<td>1.09±0.020</td>
</tr>
</tbody>
</table>

Pancreatic digestion

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>120 min</td>
<td>0.17±0.012</td>
<td>3.38±0.669</td>
<td>1.02±0.076</td>
</tr>
<tr>
<td>150 min</td>
<td>0.18±0.011</td>
<td>7.18±1.491</td>
<td>0.82±0.192</td>
</tr>
<tr>
<td>180 min</td>
<td>0.17±0.009</td>
<td>7.53±2.534</td>
<td>0.89±0.143</td>
</tr>
<tr>
<td>210 min</td>
<td>0.14±0.025</td>
<td>6.28±1.261</td>
<td>1.07±0.030</td>
</tr>
<tr>
<td>240 min</td>
<td>0.17±0.015</td>
<td>3.58±1.458</td>
<td>1.04±0.087</td>
</tr>
</tbody>
</table>

3.3 Acknowledgments
Funding for this research was provided by The Thailand Research fund (TRF), Thailand.

4. References


ICCBES-1342
Antifungal Activity of Crude Extracts of Some Medicinal Plants against Curvularia lunata, The Pathogen of Dirty Panicle Disease in Rice

Sanit Sawatdikarn
Department of Agricultural Science, Faculty of Science and Technology
Phranakhon Si Ayutthaya Rajabhat University, Thailand
E-mail address: ssanit33@hotmail.com

The present study was aims to test and evaluate the antifungal activity of the ethanolic crude extracts from forty-six medicinal plants were tested against Curvularia lunata (the pathogen of dirty panicle disease in rice of Thailand) by poisonous food technique at 0, 1,000, 2,500, 5,000, 7,500 and 10,000 ppm. The inhibition of mycelial growth was evaluated. The dirty panicle disease are distributed and recognized as the most important seed disease in rice of Thailand.

From the testing, All the used of forty-six crude extracts showed significant antifungal activity against C. lunata. The result showed that the Syzygium aromaticum and Origanum vulgare crude extracts showed 100% inhibition of mycelial growth at all concentrations, whereas, the Sorghum bicolor and Astragalus mongolicus crude extracts at 10,000 ppm gave the lowest inhibition of 27 and 40%, respectively.

The study impressed that the S. aromaticum and O. vulgare crude extracts plants showed the completely control of mycelial growth and probably of biological control should be an important of dirty panicle disease management in rice.

Keywords: Antifungal activity, dirty panicle disease, C. lunata, medicinal crude extract, Rice

Introduction
Curvularia species are important fungal pathogens causing seed borne diseases of many crops world wide. The dirty panicle disease is a major disease problem caused by Curvularia sp. around the locations in rice production of the world and rice production grown in Thailand and the tropical location (Ou, 1985). Abdelmonem (2000) reported this disease from different location caused by several pathogens; Fusarium sp., Alternaria sp., and Curvularia sp. The panicle dirty disease control in rice production had five methods namely mechanical control, cultural control, biological control, chemical control and integrated control. For the chemical control is the best method for dirty panicle disease, whereas this method as harmful for environmental condition, product residues and human health.
Although, with the application of several fungicides can be controlled but the toxicity effects on products in human health and environmental issues are studies. Nowadays, the farmers use the biological control for dirty panicle control in rice. Natural plant products have the potential as safe alternatives for chemical fungicides in rice disease managements. The medicinal herb crude extracts for the seed borne pathogen control have attracted wide interest. In general, several researches have been conducted on medicinal herb crude extracts and essential oils to control of plant disease. (Nwachukwu and Umechuruba, 2001; Kritzinger et al., 2002; Palhano et al., 2004; Velluti et al., 2004)

Many experiments reported of some Zingiberaceae species for antimicrobial activity, Saleem et al. (2011) studied the antimicrobial activity of essential oil of two plants (Curcuma longa and Curcuma aromatica) against Escherichia coli, Pseudomonas aeroginosa and Staphylococcus aureus and found that the essential oil of two plants can completely inhibit the growth of three pathogens. Husein et al. (2009) working on antimicrobial activity of crude extracts from Curcuma xanthorrhiza against three pathogen namely E. coli, S. aureus and Bacillus cereus, found that the ethanol extract inhibited S. aureus and B. cereus and ethyl acetate extract inhibited E. coli. Johnny et al. (2011) tested rhizome extracts of Alpinia galanga extracted by methanol, chloroform and acetone against Collectotrichum capsici at 0.01 0.10 1.00 and 10.0 µg/ml concentrations and found that methanol, chloroform and acetone extracts showed the highest of inhibition of radial growth at 10.0 µg/ml concentrations. Sawatdikarn (2011) studied the antifungal activity of crude extracts of six Zingiberaceae species namely Boesenbergia pandurata, Zingiber officinale, Zingiber cassumunar, Amonum xanthioides, Kaempferia galanga and Amonum krervanh against Curvularia sp. (the pathogen of dirty panicle disease in rice), selected crude extracts of B. pandurata at 1,000 ppm showed the highest of mycelial growth inhibition for 57.8% and the crude extracts of A. Krervanh at 1,000 ppm showed the lowest of mycelial growth inhibition for 43.7%.

Many experiments reported of some plants crude extracts and essential oil for antimicrobial activity. Lee et al. (2001) tested essential oils of Origanum vulgare for their antimicrobial activities against four plant pathogens (Botrytis cinerea, Collectotrichum gloeosporioides, Pythium altimum and Rhizoctonia solani), selected essential oils of Origanum vulgare showed the inhibition of mycelial growth for 65 68 78 and 92% of B. cinerea, R. solani, C. gloeosporioides and P. altimum, respectively. Bansod and Rai (2008) tested plant extracts (Allium sativum) for their efficacy against Aspergillus fumigatus and found extract of A. sativum at 100 µg/ml to completely inhibit the mycelial growth of A. fumigatus. Owalabi et al. (2010) reported that the pure extract of Eupatorium odoratum can completely inhibit the mycelial growth of Bacillus cereus and Aspergillus niger. Ali et al. (2010) noted the extract of Piper betle on the mycelial growth of four pathogens namely Aspergillus flavus, A. niger, A. fumigatus and A. paraciticus and found that the extract showed maximum inhibition of the
mycelial growth of the pathogens. Ogebor and Adekunle (2005) tested 21 plants extracts on the mycelial growth against *Corynespora cassiicola* (the pathogen of leaf spot of para rubber) under laboratory condition and found extract of *Synedrella nodiflora* showed the inhibition of mycelial growth for 34.8%. Soetan *et al.* (2006) reported that the seed extract of *Sorghum bicolor* on the mycelial growth of *Staphylocooccus aureus* under laboratory condition and found that 25 mg/ml seed extracts of *S. bicolor* showed the highest of inhibition on the mycelial growth of the pathogen.

No information of forty medicinal herb crude extracts on inhibition of mycelial growth of *C. lunata* (the pathogen of dirty panicle disease of rice). The objective of this research was to evaluate of forty medicinal herb crude extracts on the mycelial growth of *C. lunata* in central area of Thailand.

**Materials and Methods**

This work was conducted at Department of Applied Science, Faculty of Science and Technology, Phranakhon Si Ayutthaya Rajabhat University, Phranakhon Si Ayutthaya during 2010-2011 to determine the antifungal activity of *Boesenbergia pandurata, Curcuma longa, Zingiber officinale, Alpinia galanga, Zingiber cassumunar, Amonum xanthioides, Kaempferia galanga, Curcuma aromatica, Curcuma xanthorrhiza, Kaemferia parviflora, Amonum krervanh, Syzygium aromaticum, Allium sativum, Allium ascolonicum, Cymbopogon citratus, Cymbopogon nardus, Leptochloa chinensis, Eupatorium odoratum, Piper betle, Synedrella nodiflora, Cassia siamea, Sorghum bicolor, Rosmarinus officinalis, Origanum vulgare, Chrysanthemum indicum, Polygonum odoratum, Glycyrhiza glabra, Piper longum, Codonopsis pilosula, Astragalus momglolicus, Paeonia lactiflora, Illicium verum, Dioscorea opposite, Citrus hystrix, Ocicum gratissimum, Eucalyptus camaldulensis, Millingtonia hortensis, Anethium graveolens, Eryngium foetidium and Laurus nobilis* against *C. lunata* (the pathogen of dirty panicle disease in rice) in sterile distilled water and ethanol by using food poisoning technique (Prasad *et al.*, 2010)

**Preparation of Rice Seeds and Isolation of Pathogen**

Rice seeds were obtained from three location in Central area, Phranakhon Si Ayutthaya, Aungthong and Prathumthani Province. *C. lunata* from the rice seeds were isolated and maintained on petri dishes containing in Potato dextrose agar (PDA) and incubated at 25°C for 3 days before the tests.

**Collection and Preparation of Plants Samples**


Forty medicinal crude extracts used in this study was obtained from three location in Phranakhon Si Ayutthaya province, Bangban, Wangnoi and Bangpa-in, where produce and export of medicinal herb productions. There were washed with tap water and air dried for three days to eliminate surface moisture. Then each part of medicinal plants were packed in to envelop and kept in oven at 80°C temperature until dried. Dried each parts were grinded separately in an electic grinder to obtain powder which was than kept in plastic bags before the tests.

**Preparation of Crude Extracts**

100 grams of the dried powdered plant were soaked in 1,000 ml of 90% ethanol. These mixtures were refluxed followed by agitation at 200 rpm for 1 hour. The ethanolic extracts were squeezed and filtered by muslin cloth. The crude extracts were placed in to a wide tray to evaporate ethanol and added with water plant extracts (Prasad et al., 2010)

**Mycelial Growth Test**

Food poisoning technique; Diffusates were added in PDA and poured into petri dishes. PDA medium added only with ethanol and water served as control treatment. Each petri dishes was inoculated with 5 mm plug of pure isolate taken from margins of actively growing culture of pathogen. All petri dishes were incubated at 25°C.

The screening of crude extracts for antifungal activity was conducted using the agar dilution method. Different crude extracts were tested using food poisoning technique. Each tested crude extracts was used at different concentrations; 0 (control treatment), 1,000, 2,500, 5,000, 7,500 and 10,000 ppm. The petri dishes were incubated in room temperature for 7 days. The efficacy of treatment was assessed from all the four plate by measuring fungal colony development (cm). The mycelial growth inhibition (M) with respect to the control treatment was calculated from the formula (Sheng-Yang et al., 2005)

\[
M = \frac{(A-B)}{A} \times 100
\]

Where A is the colony diameter of the control treatment and B is the colony diameter of the treated of crude extracts.
Results and Discussion

The forty medicinal plant crude extracts showed inhibition on mycelial growth of *C. lunata* at different concentrations (Table 1). The crude extracts of *S. aromaticum* and *O. vulgare* showed 100% inhibition on mycelial growth at all concentrations whereas, the *S. bicolor* and *A. monglolicus* crude extracts at 10,000 ppm gave the lowest inhibition of 27 and 40%, respectively.

For the clove (*S. aromaticum*) and origano (*O. vulgare*) crude extracts showed 100% inhibition on mycelial growth at all concentration can be used crude extracts of these species for *C. lunata* control (the pathogen of dirty panicle disease in rice) at all concentration (1,000-10,000 ppm). These results are in agreement with that the researches of Kritzinger *et al.* (2002), Lee *et al.* (2002) and Prasad *et al.* (2010). For the crude extracts of *S. bicolor* and *A. monglolicus* showed inhibition of mycelial growth of *C. lunata* that related to the researches of Ogebor and Adekunle (2005) and Soetan *et al.* (2006).

The four crude extracts, namely *B. pandurata*, *C. longa*, *A. xanthioides* and *K. galanga* showed 100% inhibition of mycelial growth at 7,500-10,000 ppm. These results have been confirmed by some researches, for examples Sawatdikarn (2011) noted the three plant crude extracts in Zingiberaceae species namely *B. pandurata*, *A. xanthioides* and *K. Galanga* at 10,000 ppm concentrations showed the highest of inhibition on mycelial growth of *Curvularia* sp. for 100 100 and 95%, respectively. In another study, Saleem *et al.* (2011) who studied essential oil of *C. longa* against three pathogens, including *E. coli*, *P. aeroginosa* and *S. aureus* and found that the essential oil of *C. longa* showed the highest 100% inhibition of the pathogens.

For lemongrass (*C. citratus*) crude extracts showed the inhibition on mycelial growth of *C. lunata* for 56-100% at 1,000-10,000 ppm concentrations, that research is related to the lemongrass (*C. citratus*) essential oil for the inhibited on mycelial growth of some pathogen; *Collectotrichum gloeosporioides* (Palhano *et al.*, 2004) *F. moniliforme* (Nwachukwu and Umechuruba, 2001) and *Fusarium verticillioides, F. proliferatum* and *F. graminearum* (Velluti *et al.*, 2004) and the essential oils of lemongrass showed the inhibition of microbial agent in storage of some seeds; maize and cowpea (Adegode and Odesola, 1996) and melon (Bankole and Joda, 2004). The phytochemical from lemongrass crude extracts showed the inhibition on mycelial growth *Fusarium* sp. because of decreased of hyphal diameter and hyphal wall, plamamembrane disruption, microcondrial structure disorganization and inhibitor of biodegradation and storage contaminating fungi (Hetal *et al.*, 2006).

For the crude extracts of *E. odoratum* showed the inhibition at 10,000 ppm for 100 % of mycelial growth of *C. lunata*.These results are in agreement with that the researches of Owalabi *et al.* (2010). In other side, the crude extract of *C. siamea* had 100% inhibition at 10,000
ppm (Table 1) showed agree with the antifungal activity of *C. siamea* crude extract against fungal growth in grain maize storage (Chatterjee, 1990) and the methanolic extracts of *C. siamea* exhibited strong antibacterial activities namely *B. cereus, L. monocytogenes* and *S. aureus* (Nanasombat and Teckchuen, 2009).

The objective of this study was to screen of forty crude extracts on the mycelial growth of *C. lunata*. The usage of all crude extract was the best for *C. lunata* control due to their harmless on enviromental condition, to user and to consumer, the study that the related to the several researcher have noted the antifungal activity of crude extracts and essential oils including, the crude extracts in Zingiberaceae species namely *B. pandurata, A. xanthioides* and *K. Galanga* for *Curvularia* sp. (the pathogen of dirty panicle disease of rice) (Sawatdikarn, 2011), the lemongrass (*C. citratus*) essential oil for the inhibited on mycelial growth of some pathogen; *Collectotrichum gloeosporioides* (Palhano et al., 2004) *F. moniliforme* (Nwachukwu and Umehuruba, 2001) and *Fusarium verticillioides*, *F. proliferatum* and *F. graminearum* (Veluti et al., 2004) and the essential oils of citronella grass (*C. nardus*) for *Phomopsis azadiractae* (the causative agent of die-back disease of neem) control (Prasad et al., 2010).

The phytochemical of each crude extracts to inhibited the mycelial growth of *C. lunata* these results have been confirmed by several researches, for examples alkaloids and flavanoids from the leaves of *S. nodiflora* (Bhogaonkar et al., 2010), saponins and tannins from the leaves of *S. bicolor* (Soetan et al., 2006), methoxyflavone from the rhizome of *K. parviflora* (Kummee et al., 2008), alpha-pinene and beta-pinene from the leaves of *E. odoratum* (Owalabi et al., 2010), carnosic acid and rosmarinic acid from the leaves of *R. Officinalis* (Frankel et al., 1996) and curcumin from the rhizome of *C. xanthorrhiza* (Husein et al., 2009).

This study indicated that the Forty crude extracts can use for *C. lunata* control and can be used two plant crude extracts for dirty panicle control. The crude extracts of *S. aromaticum* and *O. vulgare* showed 100% inhibition on mecelial growth of *C. lunata* (the pathogen of dirty panicle disease in rice) at all concentrations.

**Conclusions**

All the used of forty-six crude extracts showed significant antifungal activity against *C. lunata*. The result showed that the *S. aromaticum* and *O. vulgare* crude extracts showed 100% inhibition of mycelial growth at all concentrations, whereas, the *S. bicolor* and *A. monglicicus* crude extracts at 10,000 ppm gave the lowest inhibition of 27 and 40%, respectively.

**References**


Table 1 Efficacy of different concentration of some medicinal plants crude extracts on mycelial growth inhibition of C. lunata

<table>
<thead>
<tr>
<th>Medicinal herb crude extracts</th>
<th>Mycelial growth inhibition (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>1. Boesenbergia pandurata</td>
<td>80</td>
</tr>
<tr>
<td>2. Curcuma longa</td>
<td>90</td>
</tr>
<tr>
<td>3. Zingiber officinale</td>
<td>85</td>
</tr>
<tr>
<td>4. Alpinia galangal</td>
<td>50</td>
</tr>
<tr>
<td>5. Zingiber cassumunar</td>
<td>90</td>
</tr>
<tr>
<td>Medicinal herb crude extracts</td>
<td>Mycelial growth inhibition (%)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td></td>
<td>1,000 ppm</td>
</tr>
<tr>
<td>21. <em>Cassia siamea</em></td>
<td>37</td>
</tr>
<tr>
<td>22. <em>Sorghum bicolor</em></td>
<td>0</td>
</tr>
<tr>
<td>23. <em>Rosmarinus officinalis</em></td>
<td>74</td>
</tr>
<tr>
<td>24. <em>Origanum vulgare</em></td>
<td>100</td>
</tr>
<tr>
<td>25. <em>Chrysanthemum indicum</em></td>
<td>14</td>
</tr>
<tr>
<td>26. <em>Polygonum odoratum</em></td>
<td>24</td>
</tr>
<tr>
<td>27. <em>Glycyrrhiza glabra</em></td>
<td>75</td>
</tr>
<tr>
<td>28. <em>Piper longum</em></td>
<td>54</td>
</tr>
<tr>
<td>29. <em>Codonopsis pilosula</em></td>
<td>12</td>
</tr>
<tr>
<td>30. <em>Astragalus mongolicus</em></td>
<td>0</td>
</tr>
<tr>
<td>31. <em>Paenia lactiflora</em></td>
<td>0</td>
</tr>
<tr>
<td>32. <em>Illicium verum</em></td>
<td>44</td>
</tr>
<tr>
<td>33. <em>Dioscorea opposita</em></td>
<td>51</td>
</tr>
<tr>
<td>34. <em>Circus hystrix</em></td>
<td>24</td>
</tr>
<tr>
<td>35. <em>Ocicium gratissimum</em></td>
<td>71</td>
</tr>
<tr>
<td>36. <em>Eucalyptus camaldulensis</em></td>
<td>60</td>
</tr>
<tr>
<td>37. <em>Millingtonia hortensis</em></td>
<td>54</td>
</tr>
<tr>
<td>38. <em>Anethium graveolens</em></td>
<td>43</td>
</tr>
<tr>
<td>39. <em>Eryngium foetidium</em></td>
<td>62</td>
</tr>
<tr>
<td>40. <em>Laurus nobilis</em></td>
<td>73</td>
</tr>
</tbody>
</table>


