3rd International Forum on Systems and Mechatronics

September 6-9, 2010
River View Hotel, Singapore
The 3rd International Forum on Systems and Mechatronics

**FINAL PROGRAM AND ABSTRACT BOOK**

September 6-9, 2010
River View Hotel
Singapore

Organized by

Sponsored by
# Table of Contents

Welcome Message............................................................................................................................... 1
Local Organizing Committee............................................................................................................. 2
International Advisory Committee .................................................................................................... 3
Technical Programme Schedule ......................................................................................................... 4
General Guide of the Conference ....................................................................................................... 8
Abstracts of Presentations .................................................................................................................. 10
   Plenary Talk 1 ............................................................................................................................... 10
   Plenary Talk 2 ............................................................................................................................. 11
   Session: T1A Mechatronics and System Design......................................................................... 12
   Session: T1B Mechatronics, System Design and Modeling ........................................................... 18
   Session: T1C Functional Materials and Integration of Mechatronic Sensors/Devices/Systems25
   Session: T2A Neuroengineering Systems: Neuro-Sensing............................................................ 30
   Session: T2B Neuroengineering Systems: Neuro-Imaging and Stimulation................................. 36
   Session: T2C Intelligent Robots .................................................................................................. 42
   Session: W1A Energy System ........................................................................................................ 47
   Session: W1B Mechatronics in Manufacturing I.......................................................................... 53
   Session: W1C Mechatronics in Manufacturing II........................................................................ 59
Welcome Message

On behalf of the organizing committee of the 3rd International Forum of Systems and Mechatronics (IFSM-2010), I would like to extend my warmest welcome to all of you. The first and second International Forum of Systems and Mechatronics, IFSM-2006 and IFSM-2007, were held in Tainan, Taiwan and organized by the National Cheng Kung University, Taiwan. This IFSM-2010 is jointly-organized by the National University of Singapore and the National Cheng Kung University, with authors and delegates from countries or regions covering Australia, China, Japan, Singapore, Taiwan, and USA.

In this year’s IFSM, new topics have been introduced. The topics covered in IFSM-2010 are: Functional Materials and Integration of Mechatronic Sensors/Devices/Systems, Intelligent Robots, Mechatronics in Manufacturing, Neuroengineering Systems, Energy Systems, Mechatronics and System Design, and Modeling and Computational Systems for Mechatronics. More than 55 papers will be presented in this IFSM.

All delegates and sponsors have played a vital role in this IFSM. Some of you have assisted in many ways to make this event a great success. On behalf of the Organizing Committee, I would like to extend my heartfelt thanks to each and every one of you. I sincerely hope that this IFSM will not only be scientifically fruitful but also socially helpful, promoting comradeship and fellowship between peoples of various cultural backgrounds which will subsequently nurture over the years.

I hope that you will also take this opportunity to enjoy Singapore and make this visit your most delightful and memorable experience.

With my best wishes,

Xiaoping Li
Chairman, IFSM-2010
Local Organizing Committee

Chair:
Xiaoping Li, NUS, SINGAPORE

Co-Chairs:
Yunfeng Zhang, NUS, SINGAPORE
Gee-Pinn Too, SNME, NCKU, TAIWAN
Liang Gao, HUST, CHINA

Members:
Jerry Y. H. Fuh, NUS, SINGAPORE
Li Lu, NUS, SINGAPORE
Chenggen Quan, NUS, SINGAPORE
Wen Feng Lu, NUS, SINGAPORE
Cuntai Guan, ASTAR, SINGAPORE
Kaiquan Shen, NUS, SINGAPORE
Jie Fan, NUS, SINGAPORE
Chien-Hsing Lee, NCKU, TAIWAN
Jia-Jin Jason Chen, NCKU, TAIWAN
Min-Fu Hsieh, NCKU, TAIWAN
Tsing-Iuan James Tsay, NCKU, TAIWAN
J.J. Wang , NCKU, TAIWAN
International Advisory Committee

Chair:
Fue-Wen Frank Liou, University of Missouri, USA

Members:
Jun Wang, UNSW, AUSTRALIA
David G. Dorrell, MEMS, UTS, AUSTRALIA
Chongxun Zheng, XJTU, CHINA
Han Ding, HUST, CHINA
Shinichi Yokota, Tokyo Inst. of Tech., JAPAN
Toshiyuki Obikawa, University of Tokyo, JAPAN
CheolGi Kim, Chungnam National University, KOREA
Ru-Min Chao, SNME, NCKU, TAIWAN
Ming-Chang Shih, ME, NCKU, TAIWAN
Wen-Teng Wu, NCKU, TAIWAN
Nitish V. Thakor, JHU, USA
Steven Y. Liang, ME, GIT, USA
Placid M. Ferreira, UIUC, USA
Yiming (Kevin) Rong, WPI, USA
Gene Jean-Win Hou, ODU, USA
## Technical Programme Schedule

<table>
<thead>
<tr>
<th>Time</th>
<th>September 6, 2010 (Monday)</th>
</tr>
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<tbody>
<tr>
<td><strong>1800 – 2000</strong></td>
<td><strong>REGISTRATION RECEPTION</strong> <em>(Outside Peony Room @ Level 2)</em> AND <strong>BUFFET DINNER</strong> <em>(River Garden Coffee House @ Level 1)</em></td>
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</tbody>
</table>

### September 7, 2010 (Tuesday)

<table>
<thead>
<tr>
<th>Time</th>
<th>Session: T1A (Camellia Room @ Level 4) Mechatronics and System Design</th>
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<tbody>
<tr>
<td><strong>0800 – 1700</strong></td>
<td><strong>REGISTRATION</strong> <em>(Outside Camellia Room @ Level 4)</em></td>
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<tr>
<td><strong>0850 – 0900</strong></td>
<td><strong>OPENING ADDRESS</strong></td>
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<tr>
<td><strong>0900 – 1000</strong></td>
<td><strong>PLENARY TALK</strong> <em>(Camellia Room @ Level 4)</em> Chair: Yunfeng ZHANG Multi-scale Abrasive Jet Machining for High Integrity Manufacturing Speaker: Jun WANG</td>
</tr>
<tr>
<td><strong>1000 – 1020</strong></td>
<td><strong>MORNING TEA BREAK</strong></td>
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<tr>
<td><strong>1020 – 1050</strong></td>
<td><strong>Session: T1A</strong> <em>(Camellia Room @ Level 4)</em> Mechatronics and System Design</td>
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<tr>
<td></td>
<td>Session Chair: Mingcong DENG Session Co-chair: Ming-Chang SHIH</td>
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<tr>
<td></td>
<td><strong>Session: T2A</strong> <em>(Hibiscus Room @ Level 3)</em> Neuroengineering Systems: Neuro-sensing</td>
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<td></td>
<td>Session Chair: Jia-Jin Jason CHEN Session Co-chair: Cuntai GUAN</td>
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<tr>
<td></td>
<td><strong>IFSM033I</strong> <em>(Invited Talk)</em> Operator Based Fault Detection System Design for Actuator of a Thermal Process Mingcong DENG <strong>IFSM009I</strong> <em>(Invited Talk)</em> Evaluation of the Effect on Dispelling Mental Fatigue for Eye Massager by Physiological Measurements Shyh-Yueh CHENG, Chi-Min SHU, Jia-Jin Jason CHEN</td>
</tr>
<tr>
<td><strong>1050 – 1105</strong></td>
<td><strong>IFSM005</strong> A Study on Anti-lock Brake System of A Motorcycle Ming-Chang SHIH, Chun-Kuei HUANG</td>
</tr>
<tr>
<td><strong>1105 – 1120</strong></td>
<td><strong>IFSM008</strong> A Study on Optimization Design of Hydrostatic Bearing Parameters Jen-Sheng SHIE, Ming-Chang SHIH</td>
</tr>
<tr>
<td><strong>1120 – 1135</strong></td>
<td><strong>IFSM009</strong> Capstone Design Project Experience on Autonomous Surface Vehicles Gene HOU, James G.-P. TOO, Steve HSIUNG</td>
</tr>
<tr>
<td><strong>1135 – 1150</strong></td>
<td><strong>IFSM010</strong> Application of A Marine Dynamic Positioning System using CAN Min-Fu HSIEH and I-Hsien LIN</td>
</tr>
<tr>
<td><strong>1150 – 1205</strong></td>
<td><strong>IFSM025</strong> MR Compatible Robot for Minimally Invasive Surgery Shan JIANG, Peng ZHENG, Jun LIU, Jun YANG</td>
</tr>
<tr>
<td><strong>1205 – 1220</strong></td>
<td><strong>IFSM040</strong> Variations of Skin Impedance with Time for Different Electrolyte-Skin Contact Surface Areas and Body Sites W. C. NG, Y. J. FANG, Y. WANG, W. L. KHOA and X.P. LI</td>
</tr>
<tr>
<td><strong>1230 – 1400</strong></td>
<td><strong>LUNCH</strong> <em>(Executive Lounge @ Level 3)</em></td>
</tr>
<tr>
<td><strong>1400 – 1430</strong></td>
<td><strong>Session: T1B</strong> <em>(Camellia Room @ Level 4)</em> Mechatronics, System Design and Modeling</td>
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<td></td>
<td>Session Chair: C. QUAN Session Co-chair: Wen F. LU</td>
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<tr>
<td></td>
<td><strong>Session: T2B</strong> <em>(Hibiscus Room @ Level 3)</em> Neuroengineering Systems: neuro-imaging and Stimulation</td>
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<td></td>
<td>Session Chair: Shiyun SHAO Session Co-chair: Kaiquan SHEN</td>
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<thead>
<tr>
<th>Time</th>
<th>Session: T1B (Continued)</th>
<th>Session: T2B (continued)</th>
</tr>
</thead>
</table>
| 1430 – 1445 | **IFSM043**  
A Physics-Based Simulation System for Real-Time Interaction with Haptic Feedback in Product Design  
Jinling WANG and Wen F. LU | **IFSM011**  
Application of Near Infrared Spectroscopy for Evaluating the Influence of Sleep Deprivation to Cerebral Autoregulation  
Chao-Chen LO, Ting-Chuan HO, Pei-Yi LIN, Jia-Jin Jason CHEN |
| 1445 – 1500 | **IFSM014**  
Implementation and Analysis of A Cymbal Transducer  
Gee-Pinn James TOO, Zen-Jie LEE, Yun-Hui LIU, Chih-Hao CHOU | **IFSM013**  
Application of Near Infrared Spectroscopy and Electroencephalography to Assessment the Brain Activity under Different Workload  
Chao-Chen LO, Jia-Jin CHEN, Shyh-Yueh CHENG |
| 1500 – 1515 | **IFSM015**  
Study of Foot and Ankle Kinematics During Stance Phase of Normal Walking  
Xue WANG, Wen Feng LU, Han Tong LOH, Yoke San WONG, Fook Rhu ONG | **IFSM036**  
Functional Neuroimaging of Circadian Mental Fatigue  
Bui Ha DUC, Xiaoping LI |
| 1515 – 1530 | **IFSM021**  
Design and Verification of Aerodynamic Performance of a 1k Watt Horizontal Axis Wind Turbine (HAWT) Blade  
F.B. HSIAO, C.J. BAI, Y.J. CHEN, Y.W. CHEN | **IFSM042**  
Multi-scale Spatio-Temporal EEG Dipole Source Localization  
Yue WANG, Xiaoping LI |
| 1530 – 1545 | **IFSM007**  
Crack Identification of Beams and Plates by Using Neural Network Method and Discrete Wavelet Transform  
Joe Ming YANG, Cheng Neng HWANG, Wei Ming TSUNG and Zhe Ming ZHANG | **IFSM022**  
A Temporal Combination Stimulation Method with Multiple Frequencies for SSVEP-based Brain-computer Interface  
Jun XIE, Guanghua XU, Feng ZHANG |
| 1545 – 1600 | **IFSM049**  
Automatic Generation of Multi-cutter Tool-paths in 5-axis Finish Cut of Sculptured Surfaces  
H. Y. LI, Y. F. ZHANG, and L. GENG | **IFSM041**  
Using Sounds to Differentiate Emotional States: An ERP Study  
Rohit TYAGI, Xiaoping LI |
| 1600 – 1630 | **Session: T1C** (Camellia Room @ Level 4)  
Functional Materials and Integration of Mechatronic Sensors/Devices/Systems  
Session Chair: Ru-Min CHAO  
Session Co-chair: Jie FAN | **Session: T2C** (Hibiscus Room @ Level 3)  
Intelligent Robots  
Session Chair: Gee-Pinn TOO  
Session Co-chair: Liang GAO |
| 1630 – 1700 | **IFSM001I (Invited Talk)**  
A Flexible Thin Film SWC/PA/Parylene Piezo-resist Sensor using Transfer Printing Process  
Chih-Chao HSU, Ru-Min CHAO, Chien-Wei LIU, Steven Y. LIANG | **IFSM010I (Invited Talk)**  
A Multi-objective Genetic Algorithm for Fuzzy Flexible Job-shop Scheduling Problem  
Xiaojuan WANG, Liang GAO, Chaoyong ZHANG, Chunjiang ZHANG |
| 1700 – 1715 | **IFSM029**  
Preparation of Fibre Containing Multiple Amorphous Microwires  
Yangyong ZHAO, Yong ZHANG | **IFSM057**  
Development of an Intelligent Framework for a Web-Based Semantic Robot  
K.Z. TANG, S. TANG, S.R. HETTIARACHCHI |
| 1715 – 1730 | **IFSM037**  
Magnetic Anomaly Detection System based on Magnetic Sensor Array  
Jie FAN, Martin TAN Hwai Yuen, X.P. LI | **FSM012**  
Speech Intelligence by Use of Time Reversal Method and MEMS Array Microphones for Cell Phones  
Sheng-Che LIN, Bo-Hsien WU, Gee-Pinn TOO, Shyang-Jye CHANG |
| 1730 – 1745 | **IFSM040**  
In-vivo Measurement of the Effect of Compression Loading on the Human Skin Impedance  
W. C. NG, W. L. KHOA, Y. YE, Y. J. FANG and X.P. LI | **IFSM006**  
The Integrated Design of Adaptive Fuzzy-H∞ Controller and its Application on Robots  
Cheng Neng HWANG, Joe Ming YANG, Jen hsiang WANG |
| 1745 – 1800 | **IFSM052**  
Feature Analysis in Tool Condition Monitoring – A Case Study in Titanium Machining  
Jie SUN, Yoke San WONG, Geok Soon HONG and Mustafizur RAHMAN | **IFSM023**  
Sensor Fusion and Soft Computing Based Intelligent Behavior Control System for the Autonomous Mobile Robot  
Truong Minh DAT, Neil NIEH, Wijaya Nuru LHO TIMAH, Luu Quoc DAT, Min-Fan Ricky LEE |
<table>
<thead>
<tr>
<th>Time</th>
<th>September 8, 2010 (Wednesday)</th>
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<tbody>
<tr>
<td>0830 – 1700</td>
<td><strong>REGISTRATION</strong> (outside Camellia Room @ Level 4)</td>
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<tr>
<td>0900 – 1000</td>
<td><strong>PLENARY TALK</strong> (Camellia Room @ Level 4)</td>
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<td>Chair: Wenfeng LU</td>
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<td></td>
<td>Rapid Manufacturing and Its Emerging Applications</td>
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<td>Speaker: Fuewen Frank LIOU</td>
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<td>1000 – 1020</td>
<td><strong>MORNING TEA BREAK</strong></td>
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<tr>
<td>1020 – 1050</td>
<td><strong>Session: W1A</strong> (Camellia Room @ Level 4)</td>
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<td></td>
<td>Energy System</td>
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<td>Session Chair: Min-Fu HSIEH</td>
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<td>Session Co-chair: L. LU</td>
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<td><strong>IFSM018</strong> (Invited Talk)</td>
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<tr>
<td></td>
<td>The Integrated Design of a Permanent-Magnet Generator for Small Wind Energy Conversion System</td>
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<td>Min-Fu HSIEH and Yu-Han YEH</td>
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<td>1050 – 1105</td>
<td><strong>IFSM003</strong></td>
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<tr>
<td></td>
<td>A New MPPT Algorithm for Operating on A Moving Vehicle</td>
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<td>Shih-Hung KO, Ru-Min CHAO, Po-Long CHEN, Henry PAN, Jason CHU</td>
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<tr>
<td>1105 – 1120</td>
<td><strong>IFSM001</strong></td>
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<tr>
<td></td>
<td>Implementation of A Supercapacitor-Based Energy Storage System for Applications in a Fishing Vessel</td>
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<td>Chien-Hsing LEE, Shih-Hsien HSU, We-Je LIANG</td>
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<td>1120 – 1135</td>
<td><strong>IFSM026</strong></td>
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<tr>
<td></td>
<td>Attempt on Improving Property of Highly-densified Biomass Resources for Renewable Energy</td>
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<td>Norio MATSUURA, Masashi NARITA, Tsunehisa MIKI, Kozo KANAYAMA and Norio TAKAKURA</td>
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<td>1135 – 1150</td>
<td><strong>IFSM047</strong></td>
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<tr>
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<td>Toward Lead-Free Piezoelectric Ceramics – Future materials for sensing, actuation and energy harvesting</td>
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<td>Shukai YE, J. FUH, L. LU</td>
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<tr>
<td>1150 – 1205</td>
<td><strong>IFSM048</strong></td>
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<tr>
<td></td>
<td>Mechanical Responses to Electrochemical Cycling of Anode Film in Lithium Ion Microbatteries</td>
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<td>J. ZHU, K.Y. ZENG, and L. LU</td>
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<tr>
<td>1230 – 1400</td>
<td><strong>LUNCH</strong> (Executive Lounge @ Level 3)</td>
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<tr>
<td>1400 – 1430</td>
<td><strong>Session: W1B</strong> (Camellia Room @ Level 4)</td>
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<tr>
<td></td>
<td>Mechatronics in Manufacturing I</td>
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<td>Session Chair: K.C. FAN</td>
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<td>Session Co-chair: K. S. LEE</td>
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<td><strong>IFSM056</strong> (Invited Talk)</td>
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<td></td>
<td>The System and Mechatronics of a Developed Micro-CMM</td>
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<td>Kuang-Chao FAN, Fang CHENG</td>
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<tr>
<td>1430 – 1445</td>
<td><strong>IFSM050</strong></td>
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<td></td>
<td>Diffusion in Annealing of Nanocrystalline NiFe/Cu Composite Wires</td>
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<td>H.L. SEET, M.J. ONG, K.S. LEE, J.B. YI, X.P. LI</td>
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<tr>
<td>1445 – 1500</td>
<td><strong>IFSM051</strong></td>
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<tr>
<td></td>
<td>Simultaneous Electrodeposition of Multiple NiFe/Cu Composite Wires for Orthogonal Fluxgate Sensor</td>
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<td>H.L. SEET, K.H. CHEUNG, K.S. LEE, X.P. LI</td>
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<tr>
<td>1500 – 1515</td>
<td><strong>IFSM028</strong></td>
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<tr>
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<td>Micro Forming and Processing of Cu-based Amorphous Wires</td>
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<td>W.B. LIAO, Y. ZHANG</td>
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<tr>
<td>Time</td>
<td>Session: W1B (continued)</td>
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<tr>
<td>1515 – 1530</td>
<td>IFSM016 Combining Full and Semi Closed Loop Synchronous Control for Dual Mechanically Coupled Ball Screw System Min-Fu HSIEH and Wei-Che CHANG</td>
</tr>
<tr>
<td>1530 – 1545</td>
<td>IFSM017 A Network-Based Real-Time Control System for Mechanically-Coupled Multi-Axis Servomechanism Min-Fu HSIEH and Kang-Yu LAI</td>
</tr>
<tr>
<td>1600 – 1630</td>
<td>AFTERNOON TEA BREAK</td>
</tr>
</tbody>
</table>
| 1630 – 1700 | Session: W1C (Camellia Room @ Level 4) Mechatronics in Manufacturing II  
Session Chair: J. J. WANG  
Session Co-chair: Yung-Kang SHEN |
| 1700 – 1730 | IFSM031I (Invited Talk)  
The Analysis of Geometric Dimension and Tolerance of Workpiece in Milling Process  
| 1700 – 1730 | IFSM058I (Invited Talk)  
The Nanostructure Effect on Optical Properties and Osteoblast-like Cell Culture by Nanoporous Alumina Template  
Jeou-Long LEE, Chih-Wei WU, Hao-Ming HSIAO, Yung-Kang SHEN, Chuan-Min HUANG, Wei-Ren CHEN |
| 1730 – 1745 | IFSM030 An Investigation of Vibration-Assisted Scribing Process for Brittle Materials  
H. N. CHIANG, S. H. LIU, J. J. WANG |
| 1745 – 1800 | IFSM045 A Hybrid Intelligent System for 3D Reconstruction from a Single Line Drawing  
Y. SUN, J. SUN, Y.T. LEE |
| 1800 – 1815 | IFSM053 Discussions of the Compliance Function in 3D Reconstruction from 2D Line Drawings  
Y. SUN, J. SUN, Y.T. LEE |
| 1815 – 1830 | IFSM032 Development of Engine Speed Sensor Test Bench  
Rui QIAN, Chengying LU, Fangfang SUN |
| 1830 – 1845 | IFSM035 A Test System for PCU based on GPIB Interface with VB Language  
Fangfang SUN, Weidong YE, and Rui QIAN |
| 1845 – 2100 | BANQUET (Hibiscus Room @ Level 3) |

<table>
<thead>
<tr>
<th>Time</th>
<th>September 9, 2010 (Thursday)</th>
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<tbody>
<tr>
<td>0845 – 0900</td>
<td>Assemble @ Hotel Lobby</td>
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<tr>
<td>0900 – 1230</td>
<td>TECHNICAL TOUR</td>
</tr>
<tr>
<td>1230 – 1400</td>
<td>LUNCH (River Garden Coffee House @ Level 1)</td>
</tr>
</tbody>
</table>
General Guide of the Conference

Conference Hotel/Venue
Riverview Hotel
382 Havelock Road
Singapore 169629
Tel: (65)6732 9922

Collection of Conference Kit and Welcome Reception (with buffet dinner at the River Garden Coffee House @ Level 1))
Outside Peony Room @ Level 2
6 September 2010 (Monday), 6.00pm to 8.00pm

Collection of Conference Kit
Outside Camellia Room @ Level 4
7 September 2010 (Tuesday), 8.00am to 5.00pm
8 September 2010 (Wednesday), 8.30am to 5.00pm

Please wear your name badge at all times. It is required for entry to all sessions and meals.

Plenary Talks
Camellia Room @ Level 4

Breakout Rooms
Camellia Room @ Level 4 &
Hibiscus Room @ Level 3

Lunch
Executive Lounge @ Level 3
12.30pm to 2.00pm

Conference Dinner
Hibiscus Room @ Level 3
8 September 2010 (Wednesday)
6.30pm to 9.00pm

Open to all registered conference delegates, including students. Please inform the Registration Table by 2.00 pm, 7 September 2010 if you are bringing your spouses.

Technical Tour
9 September 2010 (Thursday), 9.00am to 1.00pm

Assemble at hotel lobby at 8.45am

Tour to NUS

See Singapore on the Singapore Flyer

Return to hotel for lunch. Lunch will be served at the River Garden Coffee House @ Level 1.
Registration fee for the technical tour is waived for all registered conference delegates, including students. However pre-registration for participation is required.

You must register for the technical tour with the Registration Desk during the conference. Please inform the Registration Table by 2.00pm, 7 September 2010.

Internet Stations
Laptops with internet access will be setup outside Camellia Room @ Level 4 on 7 & 8 September 2010 during the conference.

Instruction for Presenters

1. Each oral presentation is limited to 15 mins (with exception of invited talk which is limited to 30 mins). The Chairs of the sessions will be keeping to the time strictly. They will sound the bell once when the 13 mins have passed. You should make a suitable conclusion to your presentation by then. There will be 2 mins Q&A immediately after your presentation.

2. Presentation should preferably be done using MS Powerpoint 2003 or compatible. A laptop with LCD projector will be made available for all sessions. To minimise technical difficulties, we request all presenters to save their presentation to a USB storage device in a format that can be read by MS Powerpoint 2003 or compatible on a Window-based PC.

3. There will not be any internet connection for the presentation laptops. You will not able to download any files from remote servers.

4. Presenters should transfer their files to the laptops as early as possible. Preferable times for presenters to load in their files are during coffee-breaks and lunch. A student assistant will be available to assist the presenters.

5. Presenters are requested to submit a short CV to the student assistant. A standard form is available at the Registration Desk.
Abstracts of Presentations

Plenary Talk 1
September 7, 2010 (Tuesday) Camellia Room @ Level 4

Multi-scale abrasive jet machining for high integrity manufacturing

Jun WANG
University of New south Wales, Australia
jun.wang@unsw.edu.au

Abrasive jet machining (AJM) is a process using high-velocity impact particles entrained by a fluid jet for the fabrication of multi-length scale structures and super-finish surfaces. Due to its various distinct advantages, such as the ability to produce surfaces and sub-surfaces of high integrity, this technology has been increasingly used in various applications; in particular it has been used as a new technology for the fabrication of components found in microfluidic, microelectro-mechanical, and opto-electronic devices. This presentation will give an overview of the technology and state-of-the-art in multi-scale AJM based on the work carried out at the presenter's laboratories over the last decade. Particular attention will be paid to the development of technologies for fabricating micro-structures of high surface integrity. A remark will finally be made on the future development in AMJ.

About the Speaker:

Jun Wang received a PhD in Mechanical and Manufacturing Engineering from the University of Melbourne, Australia, in 1993. He then worked at the same university as a Postdoctoral Research Fellow before moving to Queensland University of Technology in 1995 and then to the University of New South Wales (UNSW) in 2005. He is now Professor and Research Champion in Manufacturing Engineering at UNSW. His main research interests are in multi-length scale machining, in particular, advanced machining technologies using impacting particles and high energy beams toward damage-free fabrication of cross-scale structures. He is the Editor-in-Chief of the International Journal of Abrasive Technology, Associate Technical Editor for the international journal of Machining Science and Technology, and Associate Editor, Regional Editor and editorial board member for nine other international journals. He is also a Vice Chairman of the International Committee for Abrasive Technology, Vice President of the Ausinan Science and Technology Society, and a Fellow of the Institution of Engineers Australia.
Rapid Manufacturing and Its Emerging Applications

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This presentation summarizes the research to develop a rapid manufacturing process for high performance materials. Rapid manufacturing is the direct production of finished products or parts using additive fabrication techniques. It can eliminate tooling, and thus greatly reduce product development time and cost. Thus rapid manufacturing has profound implications for many aspects of the design, manufacturing, distribution, and sale of new products. This presentation summarizes the current additive manufacturing technologies, and the current R&D activities of a hybrid manufacturing process at Missouri S&T. The hybrid manufacturing process is based on a laser deposition process that is an additive process in which metal powder is sintered and added to the part, layer by layer, to rapidly manufacture or form the part or product to a predetermined shape directly from a CAD system. Some emerging future applications of rapid manufacturing, such as those in the areas of aerospace, bio-medical, repair/reuse, fuel cells, direct write technologies for conformal surfaces, and functionally graded materials, will also be discussed. Some challenging issues will also be identified. This research work was carried out at the Missouri S&T Laser Aided Manufacturing Processes (LAMP) lab funded by the US Air Force Research Laboratory, National Science Foundation, and many industrial partners.

About the Speaker:

Dr. Frank Liou is a Professor in the Mechanical Engineering Department at the Missouri University of Science and Technology (Missouri S&T, formerly University of Missouri-Rolla). He currently serves as the Director of the Manufacturing Engineering Program at Missouri S&T. His teaching and research interests include CAD/CAM, rapid prototyping, and rapid manufacturing. His work has been recognized and highlighted by several prestigious scholarship awards from various major academic and industrial communities, including, 3 best teaching awards, 5 best paper awards in various conferences and journals, 3 outstanding service and leadership awards, and several faculty excellence awards. He has published one book and over 180 technical papers in journal and national and international conferences, and has research grants and contracts over $10M. Professor Liou is also serving as the director of Laser Aided Manufacturing Processes (LAMP) Lab. This work has been funded by the US Air Force Research Laboratory, US Army Research Office, US National Science Foundation. Several companies have also participated in the R&D activities. Dr. Liou is a co-founder of a US company, Product Innovation and Engineering, LLC. He is a fellow of ASME since year 2008.
Session: T1A Mechatronics and System Design

Session Chair: Mingcong DENG
Session Co-chair: Ming-Chang SHIH

IFSM033I (Invited Talk)

Operator based fault detection system design for actuator of a thermal process

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Operator-based nonlinear systems design and applications have been the focus of much attention in recent years and significant progress has been made in this growing area. This talk introduces an operator based fault detection method for an actuator fault of an aluminum plate thermal process with input constraints. Operator-based robust right coprime factorization (RCF) approach is utilized in this method. A mathematical model of the thermal process is shown in an operator based presentation, a robust tracking operator system is designed for the process with input constraints. Following this, design of the fault detection system is also given by using operator-based robust RCF approach. Finally, experiment is shown.
A study on anti-lock brake system of a motorcycle

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This work presents a hydraulic anti-lock braking system (ABS) for a motorcycle. The purposes of ABS are to prevent wheel locked and keep the slip ratio at a standard value. The ABS includes a hydraulic modulator and a fuzzy controller. This hydraulic modulator is designed and tested. Fuzzy controller is used to control the hydraulic modulator, and adjust the brake pressure in calipers. The performance of the hydraulic modulator and controller are assessed by the hardware-in-the-loop (HIL) simulations. In HIL simulations, the ABS is tested on roads with one adhesive coefficient (one-phase pavement road) and different adhesive coefficients (three-phase pavement road). The hydraulic modulator performance test shows that the adjustment of pressure is more efficiently when it equipped near the calipers. The ABS can keep the slip ratio at standard value from the HIL simulation results.

Keywords: Anti-lock brake system, hydraulic modulator design, fuzzy controller, Hardware-in-the-loop simulation.
A Study on Optimization Design of Hydrostatic Bearing Parameters

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This paper describes a theoretical study concerning static performance of a square hydrostatic bearing having recesses of optimal shape parameters. Hence, the objectives of the study are to design a low friction hydrostatic bearing with high loading capacities, high stiffness, low flow rate and uniform pressure distribution. In this study, the mathematic model of a square hydrostatic bearing was simulated by applying the finite difference method to determine the performance characteristic of the proposed design. However, the optimization approach which integrated different method included Hybrid Taguchi-Genetic Algorithm (HTGA) and Gray Relational Analysis (GRA); it is the abbreviation of HTGA/Gray. The optimal parameters of a hydrostatic bearing were found such as orifice location, orifice diameter, recess width, and recess depth according to the optimal theory. Finally, the optimization results indicate the proposed hydrostatic is better ability than the general hydrostatic bearing.

Keywords: hydrostatic bearing, optimization design, recess, performance characteristic
Capstone Design Project Experience on Autonomous Surface Vehicles

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The capstone design project course is designed to challenge seniors to put to use all their acquired engineering skills and knowledge to solve a realistic design problem. The project is usually done in teams of 4-5 students and selected to be completed in a two semester course series. In the first semester, the student teams have to develop senior design proposals, submit budget request as well as write and present technical papers and conceptual designs. In the second semester, all projects must submit detailed design drawings and produce a demonstration model or prototype of their project. The course simulates an actual working environment in engineering practices in which the students must synthesize their fundamental skills via project-focused design, problem-solving, teamwork and written and oral communication within a small group. Students from both Department of Engineering Technology and Department of Mechanical Engineering at Old Dominion University (ODU) have selected the Autonomous Surface Vehicle (ASV) as their senior design project this year. A team of students from National Cheng Kung University (NCKU) also worked on the ASV design as their senior project. All of these three ASVs will participate in the 3\textsuperscript{rd} international ASV competition to be held in Virginia Beach, VA on 10-13 June 2010. The ASV project is multidisciplinary in nature, including sensors, data infusion, hull form design, controller, power supply, propeller etc. It is a challenging undertaking for both students and faculty advisors. This paper will review, document and compare the ODU’s and NCKU’s ASVs based upon their product evaluations, design processes and management strategies. The goal of this paper is to derive a set of best practices for students as well as faculty based upon the current experiences so as to guide the future capstone design projects on the ASV.
IFSM020

Application of a Marine Dynamic Positioning System using CAN

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The marine dynamic positioning (DP) is widely applied to the oil rigs or deep sea fishing vessels for long term operation at stationary position on a protean sea surface. Due to the effects of waves, wind and currents, the vehicle can be carried away from its position, dynamic positioning is necessary for vessels to maintain the attitude. Conventional marine DP is only equipped for a special purpose vehicle that increases operation cost and constraints operation field. To provide different DP application, a “customized” marine DP system is necessary; this implies thruster and its position may vary from vehicle to vehicle for sufficient propulsion to match vehicle positioning. This research proposed a DP system using 3 suspended thrusters which are installed at port, starboard, side of a vehicle for minimizing propulsion cost, distributed driver to driven the thruster, and a core controller to proceed DP. The proposed system is suitable for customizing vehicles DP application. Control area network (CAN) plays an important role for DP architecture. Traditional central system collects devices such as thruster drivers from stem to stern of a vehicle for calculation and positioning, this requires a large number of signal transmission line and increases the risk of system instability. CAN is a solution for an extendable and robust communication. Unlike central system, CAN is a serial communication, each device only requires a pair of transmission lines connect to each other. With a defined format as each device CAN interface, DP signal can simply transmit to thruster or any other extended device. Fig. 1 shows architecture of this research, and Fig.2 shows devices of the experiment arrangement.
MR Compatible Robot for Minimally Invasive Surgery

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MR compatible robot has been under consideration in last few years because of its real-time MR image guidance and reliable, precise minimally invasive interventions with reduced painfulness and recovery time. However, the MR environment creates various challenges for the development of MR compatible robot. In this research, a kind of MR compatible robot system prototype is proposed with the application of needle insertion surgery. Aiming at the special conditions of minimally invasive needle insertion surgery, the designing requirements are provided as the preliminary principle to implement our design of robotic system. As to the mechanism, three layers, double Scott-Rusell mechanism are used to construct this system. It can perform 4-DOF to adjust the position of insertion module and another one DOF to achieve the insertion action in the confined workspace. As to actuators, the synthesis of pneumatic actuator and ultrasonic motor is introduced to achieve reliable and precisely control of robot system. Ultrasonic motor is used for light load driven and pneumatic used for heavy load driven. The pneumatic servo system using on/off valves with PWM technique is presented. Fuzzy PWM method is adopted in this paper to achieve the accurate position control of the pneumatic cylinder. Material used in this robot system is still an important aspect which affects the MR image quality directly. In this research, polyformaldehyde and nylon are selected as the main material to build such a robotic system which has little influence on the MR image quality. Additionally, a preliminary validation of the prototype is made to verify our design respect to the workspace and performance requirements. PVA phantom is used to substitute the real patient. Experimental results illustrated that the controller is effective both in accurate position control, and in tracking a trajectory.

Keywords: MR compatible; Robot system; Minimally invasive surgery; Pneumatic actuator; Ultrasonic motor
Session: T1B Mechatronics, System Design and Modeling

Session Chair: C. QUAN
Session Co-chair: Wen F. LU

IFSM044I (Invited Talk)

Measurement of transparent coatings by use of vertical scanning interferometry

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In this paper, we describe a method based on white light vertical scanning interferometry (VSI) for the measurement of thickness of transparent coatings on the silicon surface. The use of a white light source in the system overcomes the phase ambiguity problem that is inevitable in conventional interferometric method. The optical arrangement is based on a modified Michelson interferometer which utilizes a reference beam and two object beams. Each object beam interferes with the reference beam and produces an interferogram. A piezoelectric transducer (PZT) moving stage with a resolution of 1 nm is used to implement vertical scanning. An algorithm based on continuous wavelet transform (CWT) is developed to retrieve the phase of a resulting interferogram, which accurately determines the local fringe peak. The retrieved envelope peaks represent the height information of points on a test surface. Tests are conducted on a semiconductor wafer and a micro-gear made of polymeric material deposited on a metal substrate. A series of interferograms are obtained on a dual-layer structure and thickness of each layer is obtained. Results show that by use of the proposed method the coating thickness can be extracted satisfactorily without phase ambiguity problem. It is shown that this method can also be used to measure transparent multi-layer structures. Figure 1 shows a schematic of the experimental arrangement. The system consists of an optical microscope, a PULNiX TM-765E CCD camera, a personal computer (PC), a Jena PZ38 PZT moving stage and a PZT controller. The optical microscope includes a Michelson interferometer, beam splitter (BS), and a lens. A transparent micro-gear of 500 μm diameter on a metal substrate as shown in Fig. 2 was measured using the proposed method. Figure 3 shows the 3D profile of the micro-gear.

Keywords: Dual-layer structure; thickness of coating; vertical scanning interferometry (VSI); continuous wavelet transform (CWT).
A Physics-Based Simulation System for Real-Time Interaction with Haptic Feedback in Product Design

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The rapid growth of computers and the internet has dramatically changed the way people obtain and exchange information, especially with the advent of virtual reality technology. By the web interface, consumers could enjoy online shopping and designers could share opinions and modifications with their colleagues globally. With virtual reality technology, the virtual prototype of the product provided by the simulation system could be used for preliminary testing and validation. Since no physical prototype is manufactured at this stage, both costs would be saved and time to market can be reduced. Moreover, besides the marketing analysis, the evaluation from potential customers could be involved in the early design stage, and thus closing the gap between the designed products and the expectation from the targeting customers. However, conventional CAD (Computer Aided Design) systems pay little attention to the interaction of human users with computers in products design.

This paper aims to develop a virtual simulation system for the product design with real-time haptic feedback. Since the force feeling plays a vital role when users manipulate products, haptic feedback as an indispensable part has to be integrated into this virtual simulation system. To fully reach the potential of such a system, the simulation of the user-product interaction has to be realistic in order to enable users to feel the physical behaviors of various products. Therefore, the physics-based modeling of the interaction between human users and products is the core of the proposed system. Due to a large variety of product materials, the interaction of human users with various physical properties needs to be modeled. Among them, the modeling of the area contact deformation between a fingertip and deformable products is the key challenge. To satisfy the requirement of the update rate for real-time haptic rendering, a simplified deformable model is proposed in this paper. Furthermore, the commercial haptic device PHANToM Desktop from SensAble Technologies is integrated into the implemented prototyping system. It is demonstrated that the proposed simulation system is accomplished for users to experience and manipulate virtual objects in cyber space. The simulation results of the proposed virtual system indicate that different force feeling is conveyed to users when they manipulate products with different material properties. During the real-time simulation, no delay is observed, and thus the proposed modeling methods are computationally efficient for real-time haptic rendering.

In the future work, an experiment will be designed to study and validate the performance of the proposed virtual simulation system.
Implementation and Analysis of A Cymbal Transducer

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Underwater transducers are widely used in underwater communication and positioning system. It is necessary to understand performance of transducer to enhance sound radiation power. In the present study, a cymbal transducer is designed and fabricated. Also, its acoustic response is analyzed. The analysis process can be divided into two stages: one is the simulation, the other is experimental measurement. In the simulation stage, dynamic responses of the cymbal transducer are calculated using a finite element analysis (FEA). Also, the effect of size of a cymbal transducer on its natural frequency is discussed. Subsequently, the dynamic responses are used in a vibro-acoustic model to predict acoustic response of the cymbal transducer. In the experimental, the sound field generated by a cymbal transducer is measured in a semi-anechoic room for radiation pattern and axial direction at natural frequency. The simulation results are in good agreements with experimental results. The work is supported by National Science Council.

Keywords: Cymbal Transducer, PZT, Acoustic.
Study of foot and ankle kinematics during stance phase of normal walking

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Study of Foot and ankle kinematics is important in clinical application such as abnormal foot functions and foot deformities. However, foot was traditionally regarded as one rigid segment. This can not fulfill the requirement of dynamic modeling of foot and ankle. Thus it requires more investigation of foot and ankle kinematics. The objective of this study is to investigate kinematics of foot and ankle during walking. This kinematic study includes joint rotation angles between sub-defined foot segments, and some new motion for describing physical features of walking. In this project, a multi-segment foot model is used with five segments: shank, calcaneus/heel, mid-foot, metatarsus and the whole foot. This model can provide five joint rotation angles (JRAS), which are angles between shank and heel (Shank-Heel), shank and foot (Shank-Foot), heel and mid-foot (Heel-Mid), heel and metatarsal (Heel-Met), and mid-foot and metatarsal (Mid-Met), in sagittal, coronal and transverse planes respectively. A system of six Vicon motion cameras is set up for foot motion capture. 16 markers are mounted over the anatomical landmarks of each young healthy volunteer’s left foot. JRAS are calculated by Vicon software-“Bodybuilder”, further processed by “MATLAB” for reducing the offset values. The JRAS of the mid-stance time are regarded as reference positions. Further more, three other dynamic motion angles are also calculated to represent specific physical features of dynamic foot motion, i.e. the windlass mechanism between for-foot and hind-foot, foot arch height changes, the push off feature during toe off phase. The experimental results show that most motions occur at the first 20% and last 20% of stance phase time. Mean and standard deviation of five joint rotation angles between segments are calculated both for one subject and all subjects. The time-histories of the five joint rotations present good agreement with previous literature. The intra-subject and inter-subject repetitions are good with small standard deviation, not only in the sagittal plane as previous literature reported, but also in the coronal and transverse planes. The results of other three dynamic motion measurements are consistent with walking physics and can more intuitively describe foot function features and have good intra-subject repeatability. This study provides a comprehensive understanding of foot and ankle motions during stance phase of normal walking. For future research, the proposed angles can be used in foot motion study of different group of people, such as the elderly and people with abnormal gait.
Design and Verification of Aerodynamic Performance of a 1k Watt Horizontal Axis Wind Turbine (HAWT) Blade

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This paper is aimed to design and verify the aerodynamic performance of a wind turbine blade for use in small capacity horizontal axis wind turbine (HAWT) of 1k watts. The method on the design procedure of the wind turbine blade first applies the blade element momentum (BEM) theory which can combine the two-dimensional (2D) airfoils in each blade’s section for generating the lift forces by virtue of pressure differences across the airfoil sections for obtaining better aerodynamic performance of the blade designed. The aerodynamic performance analysis of the blade also then employs the BEM theory in combination with the Viterna-Corrigan (VC) model to predict the lift and drag coefficients in the stall region as blade is rotating. Finally, the aerodynamic performance analysis of the HAWT blade was studied using a commercial CFD code Fluent, in which the Navier-Stokes equations were adopted to solve for a 3-D steady-state incompressible flow with k-ε turbulence model. Here, the rotating torques of the blade can also be obtained by CFD to verify the results from the BEM theory. The present results herewith have clearly shown that the CFD has proved to be a useful method for design and analysis of the HAWT blade design.
Crack Identification of Beams and Plates by Using Neural Network Method and Discrete Wavelet Transform

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The aim of this study is to find the location and the depth of the damage of an aluminum bar, and then to locate the location and the approximate length of the crack of the aluminum plate by the discrete wavelet transform and the neural network method. In numerical analysis, the first mode shapes of a damaged cantilever beam and plates are simulated by the finite element method. The obtained mode shapes of the damaged cantilever beam and plates are then transformed by the discrete wavelet transform. The mode shape values of each scale on beam or plates can be obtained and used to be the neural networks training samples, and the damage identification system for beams and plates can finally be established. In experiment analysis, several accelerometers are used to measure the vibration shapes of the beam and the plate, and the first mode shapes of the beam and plate are attained by using the wavelet packet node norm. Finally, the experimental results are used as inputs of the identification system to find the location and the approximate depth of the damage of a cantilever beam, and it can also be applied to detect the crack location and the approximate length of the crack of an aluminum plate. It is believed that the proposed crack identification system is feasible to identify the damage locations and the depths of beams as well as to identify the locations and the approximate lengths of the cracks of plates.

Keywords: Discrete Wavelet Analysis, Wavelet Packet, Neural Networks, Finite Element Analysis
Automatic Generation of Multi-cutter Tool-paths in 5-axis Finish Cut of Sculptured Surfaces

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This paper presents an optimized method for generating multi-cutter tool-paths in the finish cut of 5-axis machining. Compared to single-cutter machining, the application of multiple cutters can produce much shorter tool-paths and hence greatly reduces the machining time. In our early work, a single-cutter algorithm has been developed to generate tool-paths that are free of gouging and collision problems for the whole target surface. In this paper, this method is extended to select an optimal set of cutters which are utilized to finish different regions of a surface. For a given surface, the feasible cutters, that form all the possible cutter sets, are identified by calculating all cutters’ accessibility information. The candidate cutter sets are then extracted from all possible cutter sets by keeping every cutter’s actual cutting region sufficiently large. Based on a proposed method for estimating the cutting time without generating the tool path, the optimal cutter set with the maximum cutting efficiency is selected. Then iso-planar paths are generated for each cutter in the optimal cutter set to finish machining of the surface. Examples are given to show the validity and robustness of the developed methods.
Session: T1C Functional Materials and Integration of Mechatronic Sensors/Devices/Systems

Session Chair: Ru-Min CHAO
Session Co-chair: Jie FAN

IFSM004I (Invited Talk)

A Flexible Thin Film SWCNN/Parylene Piezo-resist Sensor Using Transfer Printing Process

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Many biomechanical engineering applications require new sensors for strain measurement. Carbon nanotubes (CNTs)/Polymer thin films have been used in some of these applications for their higher sensitivity and relatively small size than current metallic foil type strain gauges. However, previous process for fabricating CNTs/Polymer thin film strain sensor is proven time consuming and is not compatible with standard IC process. In this paper, a rapid production and IC process compatible fabrication process based on transfer printing technique is presented to demonstrate a flexible single-walled carbon nanonets(SWCNNs)/Parylene-C thin film composite structure can be used for strain sensing application. This prototype has been characterized with a commercial strain gauge using tensile test. The average gauge factor of the proposed sensor on the flexible PEN substrate was 1.61 with standard deviation of 0.15. The method to increase the sensor’s gage factor will be also discussed.

\textit{Keywords}: Carbon nanotubes (CNTs), Single-walled Carbon nanonets (SWCNNs); Parylene-C; Piezo-resist; Flexible sensor
Glass-covered Co-based amorphous microwires were produced by Taylor method. The diameter of the metallic core is between 40–50 micron and the glass cover thickness is between 10–20 micron. These wires were then aligned unidirectionally and hot pressed under a nitrogen atmosphere at 500°C to prepare fibre containing multiple Co-based amorphous microwires. The GMI (giant magneto-impedance) effect of this fibre is several times as sensitive as single glass-covered Co-based amorphous microwire wire. This fibre is prospective materials for numerous types of sensors like magnetic field, current, and torque ones due to their magnetic properties, especially super GMI effect.
Magnetic Anomaly Detection System Based on Magnetic Sensor Array

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Magnetic anomaly detection technology is able to track a ferromagnetic object and provide information about the size of the object. However, for multiple objects, a feasible inverse algorithm is not available. In this research, a magnetic sensor array using AMR sensors has been designed and developed. A novel method for multiple magnetic target detection and localization is proposed based on the k-means clustering algorithm and it only requires a simple inversion algorithm assuming the presence of a single dipole. As the clustering algorithm requires the number of natural clusters to be known a priori to perform real time detection and localization, a method of estimating the number of targets based on Gap Statistics and the Silhouette Method is introduced to perform the best estimate of the number of targets present. The proposed method is advantageous compared with the conventional multiple sources Euler Deconvolution method which has to employ higher order spatial derivatives of the magnetic signals. Numerical simulations show that the method is feasible and potentially useful. Laboratory experiments for the single target detection based on an AMR magnetic sensor array were carried out to verify the dipole model, inverse algorithm and signal processing techniques and the results are presented. The results showed a low percentage error between the estimated target location and true target location at less than 5% in simulations and maximum localization error of less than 15% in lab experiment.
In-vivo Measurement of the Effect of Compression Loading on the Human Skin 
Admittance

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Compression of the skin resulting from physical contact by dry surface-electrodes for bio-potential 
measurement has not been clearly understood. The absence of this factor in the assessment of 
electrode performance may result in an incorrect judgment of the actual performance of the 
electrode of interest. The electrical impedance of the skin is one of the key performance indices for 
bio-potential electrode. Hence, it is of great interest to characterize the dynamics of skin 
impedance that is being influenced by mechanical deformation due to contact pressure on the skin.
In this study, skin impedance was measured simultaneously with stepwise indentation on both the 
flexor and extensor forearm. Finite element method (FEM) is used to model the multilayer soft 
tissue skin to provide a complete picture of Stratum Corneum (SC) undergoing the deformation.
During the loading phase, the results showed an exponential increase in impedance corresponding 
to the indentation depth. It was also observed that the change in impedance is partially reversible 
during the unloading phase. This impedance change is postulated to be due to the change in the 
SC’s thickness with the support of the FEM results suggesting that the change in skin impedance is 
dependent on the bio-mechanical characteristics of the skin.
Due to the rapid wear of the cutting tools when machining titanium alloy, tool condition monitoring (TCM) is most useful to avoid workpiece damage and maximize machining productivity. This paper uses sensor signals and feature analysis to identify a feature set for effective TCM. Firstly, basic requirements of sensor signals in tool condition identification are discussed, and the suitability of two candidate signals (acoustic emission and cutting force) commonly employed for machining monitoring are critically analyzed. Their effectiveness in TCM is investigated based on extracted features of these signals, singly or in combination. Experimental results based on titanium machining, which is an expensive process with high tool wear, indicate that this proposed method is capable to determine a suitable sensing method and an effective feature set to identify tool condition.

*Keywords:* tool condition monitoring; feature selection; sensor fusion
Evaluation of the Effect on Dispelling Mental Fatigue for Eye Massager by Physiological Measurements

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In this study, we attempted to evaluate the effect on dispelling mental fatigue for eye massager by using physiological indices including electroencephalography (EEG) and heart rate variability (HRV). Thirty university male students divided into experimental (eye massager worn) and control (eye closed) groups participated as volunteer subjects. They are paid for their participation in the study. Participants could lead to mental fatigue during 2 hours of experimental tasks (mental arithmetic via computer). We found EEG basic indices of $\alpha$ and $\theta$ bands were decreased while $\beta$ band was increased for experiment group, and the degree was superior to the control group. In addition to basic indices, EEG ratio indices of $(\alpha+\theta)/\beta$ and $\theta/\alpha$ were decreased at the same condition, while $\beta/\alpha$ was increased for experiment group, and the degree was also superior to the control group. It revealed that the alertness level of participant wearing the eye massager increased more than that of one with eyes closed only. The value of low frequency band/high frequency band (LF/HF) ratio of HRV power for experiment group decreased significantly more than that for control group. For subjective measure, the NASA-TLX rating scale of the experiment group had more mental relaxation than that of control group. The final results appeared that the eye massager had pronounced effect on dispelling mental fatigue and psychological relaxation.

Keywords: Eye massager, Mental fatigue, Electroencephalography, Heart rate variability
Towards Sub-mW Wireless Implantable EEG Sensors

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With the advance of CMOS technologies and bio-engineering, it is envisaged that wireless implantable therapeutic (WIT) devices will revolutionize the treatment of diseases, especially for brain function disorder, in near future. Brain function disorders such as Parkinson's disease, epilepsy, tremor, chronic pain, cognitive and psychiatric disorders are caused by brain circuits malfunction, i.e. either overactive or underperforming. With the advance of brain imaging techniques such as functional magnetic resonance imaging (fMRI) and positron emission tomography (PET), the roles and locations of brain circuits in the pathogenesis of disease states are better understood. Considering that electricity is one of the currencies for transactions in the brain, it is possible to stimulate part of brain circuits to enhance the function of underperforming pathways or disrupt pathological neural activity through deep brain stimulation (DBS). DBS is a device that delivers electrical impulses to specific parts of the brain and has shown remarkable therapeutic benefits for essential tremor, Parkinson’s disease, and dystonia. DBS is being studied for treating other brain function disorders such as epilepsy, stroke, obesity, severe depression, obsessive compulsive disorder, etc. Research shows that through brain stimulation it is possible to help paralysed patients to regain their movement. The market potential for brain stimulation is enormous. The obesity market alone is estimated to exceed $100 billion. Considering the aging society, the demand for DBS may grow further in 10 years.

Multi-channel EEG signal recording is one of the core building blocks in a DBS system. This paper presents a sub-mW wireless implantable EEG sensor, which was implemented in 0.35μm standard CMOS process. The sensor contains a 22-μW reconfigurable recording front-end and a 400-μW Impulse Radio Ultra-wideband (IR-UWB) based wireless transmitter. The recording front-end chip contains a low noise amplifier, a tunable band-pass filter, a programmable gain stage, and 10-bit ADC. The IR-UWB transmitter is implemented by utilizing only digital circuits and operates in a frequency range from 300 to 800MHz.

This work is supported partially by Singapore Agency for Science Technology and Research SERC grant 092-148-0066 and National University of Singapore Academic Research Fund R-263-000-573-112.
Multi-scale Analysis of Electroencephalogram Signals in Alzheimer Disease Using Wavelet Transformation

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Objective: To study the multi-scale qualitative characteristics of the EEG signals in Alzheimer disease by multi-scale wavelet transform analysis. Methods: The case-comparative experiment was performed at the Department of Neuroelectrophysiology, Tianjin Medical University from August 2006 to May 2009. A total of 15 patients with Alzheimer disease from the General Hospital of Tianjin Medical University were enrolled in the study. In addition, 12 healthy, age- and sex-matched normal controls were also enrolled. Electroencephalogram signals were tested on the 15 patients with Alzheimer disease and 12 normal controls. The EEG records of 15 clinical Alzheimer disease patients were analyzed with multi-scale resolution by wavelet transform. The multi-scale qualitative features of Alzheimer disease were extracted, comparing with the 12 normal controls at the same age. Wavelet power spectrum is introduced, as a new promising statistic, to evidence reliable multi-scale distribution index of EEG signals. Multi-scale phase averaged waveforms were extracted from EEG signals by wavelet coefficient index using a conditional phase averaging technique. Amplitude and other features of phase average waveform for Alzheimer disease were compared with that of normal controls. Results: Through wavelet decomposition of the EEG records, transient waveform aspects are accurately captured both in time and frequency context. The narrow-band power spectrum with single frequency peak at 1Hz is the typical characteristic of EEG in Alzheimer disease, while EEG of normal controls always represent wideband power spectrum and have three typical frequency peaks at 0.1Hz, 1Hz, 10Hz. The power decreasing at low frequency (0.03Hz<\textless f<0.1Hz) and high frequency (5Hz<\textless f<50Hz) in EEG depresses the capability of complex cognitive activities and functions of human brain for Alzheimer disease. Conclusion: Wavelet transform, as a powerful tool of multi-scale analysis, is particularly effective for revealing significant aspects of Alzheimer disease EEG. More valuable qualitative information for Alzheimer disease can be obtained by wavelet analysis of EEG. These multi-scale qualitative remarkable features are helpful in clinical diagnosis and evaluation of Alzheimer disease and also can provide improved insight of the mechanisms causing Alzheimer disease.

Keywords: EEG, multi-scale, wavelet transform, Alzheimer disease
IFSM038

The Heartbeat Evoked Potential: A Neural Correlate of Pain Perception

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There has been evidence showing that pain perception can be modulated across the cardiac cycle. Therefore, it is interesting to see whether the cardiac-cycle related activity can offer use for objective measures of pain perception. Motivated by this, the present study examined the correlation between pain perception and the cardiac-cycle related brain evoked potential, termed the heartbeat-evoked potential (HEP). Simultaneous electroencephalogram (EEG) and Lead-II electrocardiogram (ECG) were recorded from 14 subjects in three conditions: a) no-task control, b) no-pain control and c) cold pain induced by 10\degree C cold pressor task. The HEP was obtained by ECG R-peak locked EEG averaging with cardiac artifact carefully excluded. Results showed that prominent HEP appeared in both control conditions, as a positive or negative (depending on channel location) deflection at a latency range of 200-600 ms post ECG R-peak. Between-condition comparisons showed that, the HEP was largely suppressed in cold pain condition compared to the control conditions, especially over the right hemisphere which is contralateral to the painful stimulation, while there was no significant difference between the mean HEP magnitudes in the two control conditions. The HEP suppression specifically in cold pain condition suggests that the HEP could be a promising objective measure of pain perception. The HEP suppression probably results from the inhibition of unconscious/subconscious cardiac interoceptive process by the perception of tonic cold pain via overlapped networks involved in both processes.
**IFSM039**

**Variations of Skin Impedance with Time for Different Electrolyte-Skin Contact Surface Areas and Body Sites**

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It is well known that an increase in the contact surface area of the interface, between the electrolyte and skin, will lead to a decrease in the measured skin impedance. There are reports which show that the measured skin impedance, upon the onset of electrode application, displays an exponential decline. However, no detailed concordance between the characteristics of the drop in measured skin impedance with time have been made on the skin of body sites with different number of SC layers, hair follicle structures and density. This paper provides insights on these differences to the variations of skin impedance with time. A modified time-dependent electrical model of electrode-skin interface and its corresponding mathematical model with dual processes exponential decay function have been proposed in this study. The low-frequency impedance of various electrolyte-skin contact areas at different body sites are measured and analysed qualitatively with the proposed electrical model. The results showed that a larger electrolyte-skin contact area, follicular surface, volume and density, have larger exponential decay time constants.
Particularly devastating injuries to the human nervous system include stroke and spinal cord injury, where a tragically localized lesion greatly impairs motor function. Unfortunately, the central nervous system is unable to repair itself, and Man has lived with the permanent effects of paralysis. Recovery of function is achieved only by neuroplasticity, which can be promoted by effective rehabilitation. Stroke is one of the major causes of disability worldwide with an estimated 75% of stroke survivors requiring specialized rehabilitation. Even after completing conventional rehabilitation, many patients still face persistent and disabling upper limb motor deficits. With the increasing aged population combined with the increased risk of stroke as a person ages, there is a need to explore alternatives to improve rehabilitation methods.

Recently, Brain-Computer Interface (BCI)-based robotic rehabilitation has surfaced as a promising method for stroke rehabilitation. BCI is a communication system that directly translates brain signals into commands for controlling an external device, which bypasses the normal motor output neural pathways and involves motor or mental imagery practice for stroke patients. BCI-based robotic rehabilitation detects the motor intent of hemiplegic patients from the Electroencephalogram (EEG) signals and uses it to drive robotic devices which enable patients to perform intensive exercises of the paretic limb. Motor imagery provides a promising means for stroke patients to recover limb movement with the aid from BCI, as regulation of their EEG may guide activity-dependent plasticity and allow the patient to be actively engaged in his/her own recovery.

Another front for BCI-based rehabilitation is the use of neuromuscular electrical stimulation, where the patient uses motor imagery to activate the movement of his/her paretic limb. It is hypothesized that this reinforcement of the efferent and afferent neural pathways could promote neuroplasticity and hence recovery of function. A BCI-triggered electrical stimulation of pharyngeal muscles to treat dysphagia is also being explored, as this would enable patients suffering from dysphagia to trigger the swallowing at a comfortable pace.

This multi-disciplinary collaboration between the Institute for Infocomm Research, National Neuroscience Institute, and Tan Tock Seng Hospital is underway in conducting a clinical trial with post-acute stroke patients to evaluate the efficacy of advanced BCI-based robotic rehabilitation approaches.
Session: T2B Neuroengineering Systems: Neuro-Imaging and Stimulation

Session Chair: Shiyun SHAO
Session Co-chair: Kaiquan SHEN

IFSM002I (Invited Talk)

Single-trial Event-Related Potential Based Rapid Image Triage System

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Searching for objects of interest in large-volume imagery is a challenging problem with few good solutions. In this work, a neural engineering approach called rapid image triage (RAIT) which could offer about a ten-fold speed up in object of interest searching is developed. It is essentially a cortically-coupled computer vision technique, whereby the user is presented bursts of images at a speed of 6–15 images per second and then neural signals called event-related potential (ERP) is used as the ‘cue’ for user seeing images of high relevance likelihood. Compared to past efforts, the implemented system has a few unique features: (1) it has an effective real-time automatic artifact removal functionality; (2) a novel common spatial-temporal pattern (CSTP) algorithm that makes use of both spatial and temporal patterns of ERP topography is proposed for high-accuracy single-trial ERP detection; (3) a weighted version of probabilistic support-vector-machine (SVM) is used to address the inherent unbalanced nature of single-trial ERP detection for RAIT. High accuracy, fast learning, and real-time capability of the developed system shown on 20 subjects demonstrate the feasibility of a brain-machine integrated rapid image triage system for fast detection of objects of interest from large-volume imagery.
Application of Near Infrared Spectroscopy for Evaluating the Influence of Sleep Deprivation to Cerebral Autoregulation

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Sleep deprivation due to lack of sleep or sleep disorder would cause poor cognition performance. Breath holding task is an important method to induce vasomotor reactivity, and thus to evaluate the function of cerebral autoregulation. The purpose of this study is to investigate the influence of sleep deprivation on cerebral oxygenation during breath holding test by using near infrared spectroscopy (NIRS). The experiments were performed twice for each subject, one with adequate sleep and one with 24hr sleep deprivation. The subject was asked to hold the breath for 15s, 25s, and 30s with adequate rest between sessions, separately. The curves of oxygen saturation line were fitted by a hyperbolic tangent line from which the time constant, inflection time, and asymptotic minimum/maximum values can be extracted. The results showed that the saturation level increased with the increasing breath holding time. The hyperbolic tangent line can fit well to represent the features of oxygen saturation curves during breath holding which can be to quantify autoregulation of vasomotor activity.
Application of Near Infrared Spectroscopy and Electroencephalography to Assessment the Brain Activity under Different Workload

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Visual display terminal is becoming widely popular all over work tasks. Due to the heavy and tedious work, the risk of occupational damage may increase. Near Infrared Spectroscopy (NIRS) and Electroencephalography (EEG) are two non-invasive methods that can monitor the brain activity and provide information of consciousness of the workers. The aim of this study is to investigate the relationship between different workloads and brain activities measured by NIRS and EEG. The hemodynamic response was recorded using a multichannel frequency domain NIRS (FD-NIRS) system-Imagent (ISS Inc.) The system is equipped with light sources of wavelengths of 690 and 830 nm and NIR detectors. Detectors of NIRS were placed near EEG electrodes surrounded by four to five sources. The NIRS data were averaged with blocks from which hemodynamic response signals were integrated. The EEG recording sites were F3, F4, O1 and O2 using Neuroscan. The alpha, beta, and theta waves were extracted from power spectrum of EEG after Fourier transform. Eight healthy young people were recruited. Subjects were asked to calculate the number of red squares in two consecutive cuboids, each with 10 seconds, presenting on the black screen and 3 seconds to type down answers. Eight blocks were presented for one level of workload. There were four levels of workload, with 6, 24, 54, 96 squares in a block. Our results showed that the activities of brain were increased with the increasing workload in bilateral frontal areas but decreased in level four of workload according to NIRS and EEG. EEG recordings showed similar pattern in occipital regions, but there was no finding in NIRS measurement. This study showed a combination of NIRS system and EEG recording for assessing the workloads. Both measurements demonstrated a good correlation in the results. The result showed that with the increasing workload, the activity of brain would increase, but the decrease of brain activity was found after a certain level of workload. This might related to additional attention was required to meet the workload demand, but the attention would decrease once the workload was too heavy.

Keywords: Near Infrared Spectroscopy, Electroencephalography, Workload
IFSM036

Functional Neuroimaging of Circadian Mental Fatigue

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Along with the increase of demanding mental effort work, sleep loss, extended work period, mental fatigue is a very common phenomenon in everyday modern life. Recently, mental fatigue has been receiving increasing attention from military, transport, health. However, very little is known about the neurobiological mechanisms underlying mental fatigue. The primary purpose of this study was to investigate neuronal activation pattern for circadian mental fatigue. An auditory discrimination task was administered to 10 subjects in a 25 hours sleepless experiment. EEG data was recorded each hour in order to obtain objective fatigue scores of subjects, which is more reliable then subjective reports used in previous researches. fMRI images were acquired at 4 time points (9am, 2pm, 3am, 9am the following day) to determine changes in subjects’ brain activation. Results showed that the circadian fatigue causes general decreased activity of the brain. Some regions were significant related to mental fatigue included: right superior temporal gyrus, left thalamus, right inferior frontal and middle frontal decreased activity with time, while activation in inferior parietal cortex was found to closely link to circadian rhythm. The results suggest that circadian mental fatigue effects neuronal activation in a particular trend.

*Keywords:* mental fatigue, circadian, fMRI.
A Temporal Combination Stimulation Method with Multiple Frequencies for SSVEP-based Brain-computer Interface

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Most of the past steady state visual evoked potential (SSVEP) based Brain-computer Interface focus on single frequency stimulation, which can be presented on computer screen by periodically changes in brightness. Due to the limitation of the computer monitor vertical refresh rate and the acceptable signal-to-noise (SNR) obtained in certain flickering frequency band, a few available frequencies can be chosen for target presentation. There a novel temporal combination stimulation method with multiple frequencies is proposed in this paper to significantly increase the target number by means of a few available frequencies. In this method, each frequency component flickers at certain periodic times and forms a stimulus sequence; all of the stimulus sequences corresponding to each frequency component are aligned temporally to form a stimulus sequence series. Then, each target is represented by such a stimulus sequence series composed of multiple frequency components. This procedure can be illustrated in Fig. 1.

![Diagram](image)

Due to the permutation of all the stimulus sequences, which are corresponding to each frequency component, \( n \) single frequencies can at most produce \( n \cdot n \cdot \ldots \cdot n = n^n \) different stimulus sequence series and \( n^n \) different targets consequently. The amplitudes of the respective frequency component of the subjects’ response are extracted and aligned as the feature to train the SWLDA classifier and the considerable classification accuracy is also obtained. Based on this method, a four-target SSVEP-based Brain-computer Interface is implemented by using of only two different frequencies and four subjects participate to the tests to confirm this method.
Emotions are part of our everyday lives, but defining and measuring emotions is still one of the major problems in Neuroengineering. Self-report subjective measures are easiest to do, but do not give an insight on the neural processes involved in eliciting emotions. Using different Neuroimaging techniques like EEG and fMRI helps in exploring the brain structures involved in emotional experiences. This study was designed to investigate if differences in ERPs could be used to predict the emotional state a person is in. The purpose of this study is to find some ERP features which occur in response to sound probes and can help differentiate between different emotional states. Three groups of images from the IAPS were used to elicit the emotional states in the subjects – low arousal and positive valenced images to induce a happy state, high arousal and negatively valenced images to induce a fear/disgust state and a group of neutral images were used to induce a neutral state to act as a control. Three kinds of sound probes were given randomly in these states – a female voice saying the words “da-da” in neutral, happy and angry prosody. EEG was collected during the experiment from 62 standard channels using the 10-20 system. After filtering and artifact removal, ERPs were calculated for the different sound probes in different emotional states and compared. It was seen that most subjects showed differences in ERPs, especially in the early phase. The results showed that subjects’ responses to the same sound probes differed when they were in different emotional states, thus making it possible to have an objective neurophysiological measure to estimate the emotional state of a person.
A Multi-objective Genetic Algorithm for Fuzzy Flexible Job-shop Scheduling Problem

Xiaojuan WANG, Liang GAO, Chaoyong ZHANG, Chunjiang ZHANG

In real-world production, processing times may vary dynamically due to human factors or operating faults and there are some other uncertain factors in the scheduling problems. In this paper, fuzzy sets are used to model uncertain due dates and processing times of jobs and a genetic algorithm based on immune and entropy principle is proposed to solve the multi-objective fuzzy flexible job-shop scheduling problem. In this proposed multi-objective algorithm, the fitness scheme based on Pareto-optimality is applied, and the immune and entropy principle is used to keep the diversity of individuals and overcome the problem of premature convergence. Efficient crossover and mutation operators are proposed to adapt to the special chromosome structure. The computational results validates the effectiveness of the proposed algorithm.
Development of an Intelligent Framework for a Web-Based Semantic Robot

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Current learning systems for robots are pre-defined by the designer or coordinator for the user. The widely-varied living patterns, capabilities and other inherent characteristics of the different users are often not taken into consideration when designing the functional contents of the robot. An intelligent learning system, that is able to customize the contents accordingly to the learning and living characteristics of each user, is developed to improve the whole learning/customizing experience between the user and the semantic robot. Furthermore, the framework is able to provide an interconnected network of robotic systems and other peripheral components for industrial and home uses.

Keywords: Learning system, intelligent semantic robot
Speech Intelligence by Use of Time Reversal Method and MEMS Array Microphones for Cell Phones.

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The purpose of this research is to construct a noise reduction system in 3G cell phones that combines time reversal method (TRM) and MEMS microphones array. TRM has advantages of compensating distortion due to path effect in propagation and signals focus at the original source location. This research contains theoretical reasoning, TRM simulations and experiments. In this research, impulse path response function is obtained by experimental approach. Then, it is used to estimate the source field at specific location. The simulations present that the procedure is effective in a free field with alternative and conditions. Both normalized cross-correlation coefficient (NCCC) and signal-to-noise ratio (SNR) are used to evaluate the simulation result. Also, the experiment is conducted to verify the simulation results in a configuration of a cell phone. The results demonstrate that the TRM procedure can separate a specific source from a combination signal of multiple sources, and increase the NCCC and SNR of the specific source signal. The anti-noise system in this research is effective to enhance the SNR by 5dB to 10dB, which significantly enhances the sound quality and clarity.

Keywords: Time reversal method, MEMS microphones array, Signal-to-Noise ratio
The Integrated Design of Adaptive Fuzzy-$H_{\infty}$ Controller and Its Application on Robots

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In the proposed controller design, the nonlinear elements in a nonlinear system are compensated by corresponding time-varying nominal terms estimated by adaptive-fuzzy logics. The composite control law guarantees the system tracking precision and the closed-loop stability by creating an $n^{th}$- order error equation where the gains are selected by the $H_{\infty}$ control strategy to ensure the robustness of the nonlinear uncertain system. To obtain an optimal control design among the set of all possible sub-optimal controllers that can meet the prescribed performances, the experimental method is used to search for the best optimal adaptive-fuzzy $H_{\infty}$ controller within the allowable design region designed to match the desired performance of the closed-loop systems. Finally, a robot manipulator is applied to be an example to demonstrate the feasibility of the proposed control methodology. In computer simulation, the fact of good tracking results shown in attached figures reveals that the adaptive-fuzzy $H_{\infty}$ controller proposed in this paper can effectively reject the exogenous disturbances and plant uncertainties.

Keywords: The Neural-Fuzzy Control law, Adaptive- Fuzzy $H_{\infty}$ Controller, Robots
This paper proposed the intelligent behavior control for the autonomous mobile robot operating in an unstructured environment with sensor uncertainties. The study implements the fuzzy logic control as the sensor fusion methodology with sonar, laser range finder on robot and the omnidirectional camera on ceiling and the obstacle avoidance and goal seeking behaviors was in a two wheeled mobile robot. Obstacles avoidance utilizing only eight sonar in P3DX is insufficient. The sonar readings are unreliable caused by poor obstacle surface reflection and out of incidence. The proposed sensor fusion architecture introduces further two additional sensors, the laser range finder and CCD camera, to further improves the reliability of the sensing capability of P3DX mobile robot. The sensory data input into the fuzzy logic controller are the target orientation and obstacle position, followed by eighteen fuzzy rules inferences. The output control actions to the mobile robot are the turning angle and robot velocity. The empirical results demonstrate that the effect due to uncertainty in sensor reading was reduced significantly and the real-time obstacle avoidance capability was enhanced upon applying the modified algorithm in this paper. The strategy of using virtual target has been improved to enable P3DX mobile robot to pass over the dead zone (U-shape, subspace) by following the wall, and turn back to original target as needed. The proposed soft computing based autonomous mobile robot behaviors control methodology can generate smoother and safer collision-free motion in real time unstructured environment.
The Integrated Design of a Permanent-Magnet Generator for Small Wind Energy Conversion System

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This paper presents the design, analysis and performance test of a 1.4 kW, radial-flux, permanent-magnet generator applied to small wind energy conversion system (WECS). In conventional WECS, the power flow involves three major components: (a) the turbine shaft mechanical power converted from wind energy, (b) the generator electrical output power converted from the turbine shaft power, and (c) the power electronics converters regulating the generator electrical power to the end users or loads. In terms of systematic design, these three components need to be considered all together to gain a maximum overall efficiency, instead of only chasing high performance of individual components. However, the turbines usually operate at a low speed in comparison with that of common electric machines. This indicates that a gear box is usually needed for the turbine blades and generators to be matched. For small wind turbines, the turbine blades may run at a higher speed and could be direct coupled with the generator without designing an over large generator (because of direct couple at low speed). In addition to the mechanical part, the voltage limit and current loads also need to be taken care between the generator and the power converter-inverters. Therefore, this paper develops an integrated design approach for radial-flux permanent-magnet generators (Fig. 1) by simultaneously considering the characteristics of turbine blades and converter-inverters for maximum electrical power generation. Finite element analysis (FEA, Fig. 2) is employed to verify the design. A prototype is made and experiments are conducted to evaluate the performance of the developed generator. In addition, the heat transmitted model is also included in the design process to increase the power rating of the generator so that the volume can be reduced. This is validated with FEA and experiments.
A New MPPT Algorithm for Operating on a Moving Vehicle

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A solar photovoltaic (PV) system usually uses a maximum power point tracking (MPPT) algorithm to maximize its power output. The traditional MPPT methods including perturbation and observation method, incremental conductance method, etc, tune its PWM duty-cycle output to track the maximum power output due to insolation change. Under overcast weather condition, these methods were proven to be less efficient due to the fast changing of solar insolation. Previously, we have shown the quadratic maximum power point tracking technique can maintain its maximum power output within 20 duty adjust (less than 200ms). Since this method is very sensitive to the sun orientation, sometimes it can not distinguish the change of solar power is from weather condition or from the dynamic motion of a moving vehicle. Therefore, a modified quadratic maximization MPPT algorithm is proposed and will be presented, and is intended to be used in a dynamic moving environment. This method will be tested under the request of Sandia MPPT Dynamic Response test to prove its superiority over the old method. A demonstration is also carried out on a small size auxiliary solar power boat to show this method can be implemented into its solar power harvesting system.

\textit{Keywords:} MPPT, Quadratic maximization, Dynamic response, Power harvesting
Implementation of a Supercapacitor-Based Energy Storage System for Applications in a Fishing Vessel

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Lead-acid batteries are usually used to start the genset engines as well as to supply electricity to navigation instruments and emergency lighting for a fishing vessel. The disadvantages of lead-acid batteries are low working voltage range, short cycle life and much longer charging times. The purpose of this paper is to present an implementation of a supercapacitor-based energy storage system (SESS) for applications in a fishing vessel. The advantages of the SESS are much faster charging times, wide output voltage range and no environmental pollution. Moreover, a preliminary study of using the SESS to supply part of the loads that are powered by diesel generators is investigated in this paper.
Attempt on Improving Property of Highly-densified Biomass Resources for Renewable Energy

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Plants absorb carbon dioxide into their body by photosynthesis, and they fix the atmospheric carbon dioxide as materials for growth and activity. By properly planning and managing planting-and-gathering, plant-based products can be renewable and sustainable. Utilization of plant biomass resources for the industrial application is one of the keys to realize a sustainable society. Especially, unused plant biomass resources such as thinned woods and edible crop wastes have a great potential for energy uses. Many attempts have been done to develop fuels from such unused biomass resources by means of gasification, liquefaction and solidification. Solidification processes are comparatively easy methods to make fuels such as pellets and briquettes, and usually consume less energy compared with gasification and also liquefaction processes in which much chemical and physical decomposition of biomasses are required. However present solidification process for unused plant biomass resources have not yet met demands of both costs and specifications of density, size-stability and calorific properties. In this study, to improve the properties of the solidification fuels from unused plant biomasses, a new hot-pressing process was invented in which biomass resources are accompanied compaction with flow deformation in a closed container during heating. The effects of compressing and temperature conditions for various plant-biomasses with specific moisture on the bulk density, size-stability against moisture and the calorific value of products were discussed. Results showed that the compactability of the biomasses was improved with increasing moisture contents and heat-holding time, and highly-densified products, those bulk density reached to roughly 1.35g/cm3, were obtained from all plant-biomasses used in the experiment. In addition, it was found that the products obtained from cedar wood chip at specific temperature and pressure conditions got improved size-stability against moisture, and they kept their shapes even in boiling water. The calorific value of the products showed about 6000 cal/cm³, which is around 60% of the coal. Therefore, some advantages of these highly-densified biomasses for energy use compared with existing solidified products were confirmed.
Toward Lead-Free Piezoelectric Ceramics – Future Materials for Sensing, Actuation and Energy Harvesting

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Piezoelectric ceramics have been extensively used in sensors, actuators, high voltage and power sources, etc. Recently, lead-free piezoelectric ceramics have attracted considerable attention due to the environmental concerns regarding the high toxicity in PZT based ceramics. In this study, a novel lead-free piezoelectric system, Ca substituted Ba(Ti0.9Zr0.1)O3 ceramics have been prepared via conventional solid state reaction. The X-ray diffraction analysis suggested that the Ba(Ti0.9Zr0.1)O3 ceramics underwent a phase transition from rhombohedral phase to tetragonal phase with increasing Ca substitution, and an MPB existed around 15% Ca substitution. The field emission scanning electron microscopy showed a dense microstructure with most uniform grains in 15% Ca substituted BZT ceramics. Excellent dielectric and piezoelectric properties were also achieved in this composition with dielectric constant $\varepsilon_r=5800$, piezoelectric constant $d_{33}=350$, $d_{31}=-117\text{pC/N}$. These results indicate that the Ca substituted Ba(Ti0.9Zr0.1)O3 ceramics are promising lead-free piezoelectric ceramics to replace PZT.
Mechanical Responses to Electrochemical Cycling of Anode Film in Lithium Ion Microbatteries

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All solid state thin film microbatteries compose at least 5 thin film layers, e.g. two current collectors, cathode, anode and electrolyte. Not like traditional bulk batteries, in the all solid state thin film microbatteries all the five thin films should be well bonded. Any small delamination will cause capacity fade, large polarization and even failure due to repeated volume changes of the cathode and anode with Li+ insertion/extraction.

Therefore we have studied the correlation between mechanical between electrochemical performance and mechanical behavior of the sputtered anode films which were deposited via rf sputtering. Through the investigation using XRD, AFM, and nanoindentation test combining with FIB and FESEM, we observed the changes in the surface morphology obviously accompanying a large increase in surface roughness, resulting in the mechanical degradation of electrode film. The induced-stress intensifies the initiation and propagation of micro-cracks, and finally leads to interfacial delamination. This study gives a comprehensive insight into the aging mechanism of the thin film electrodes in lithium ion microbatteries by providing new perspectives for thin film battery aging.

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The System and Mechatronics of A Developed Micro-CMM

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A micro coordinate measuring machine (Micro-CMM) is used for measuring the 3-D dimensions of miniature parts made from MEMS, micro forming or micro machining, such as micro gears, micro channels, micro gratings, micro lens, etc. The size of measured object ranges from meso- to micro-scale and its process accuracy requires from micron to submicron. Therefore, the required specifications of a developed Micro-CMM must have: (1) long-stroke and nano-positioning motion, nanometer resolution in each axis, and (2) tactile or optical probe with triggering or scanning capability to nanometer resolution. In this report, the novel design of a Micro-CMM is proposed. It consists of a bridge frame in pagoda shape for the probe mounting, a co-planar XY stage of Abbe error-free for the workpiece mounting, and a probe system having non-contact and tactile functions. In order to achieve long-stroke and nano-positioning travel, each axis is driven by an ultrasonic motor with specific commands for required motions. A nano optical scale is also developed for measuring the displacement to nanometer resolution. The motion is controlled by a BNN assisted PID scheme to maintain constant velocity. The entire Micro-CMM has been successfully constructed and tested. Experimental tests show the specifications can meet the requirements of Micro-CMM.
Weak magnetic field sensors have always been an area of great interest due to its immense potential applications in a wide array of fields such as magnetic anomaly detectors (MAD) in defense related industry or bio-magnetic field sensors in biomedical industry. The performance of such sensors greatly depends on the magnetic softness of the sensing elements. Thus, optimization of the post-heat treatment process is crucial as it serves to release stresses induced during the deposition process. In this study, furnace annealing was carried out on NiFe/Cu composite wires at a range of annealing temperatures from 210°C - 1050°C. Inter-diffusion of Ni and Cu was observed at annealing temperature of 350°C, with the diffusion effect more pronounced at elevated annealing temperatures. This diffusion effect, coupled with increases in the surface roughness and average grain sizes as the annealing temperature was increased, resulted in the deterioration of the magnetic properties and sensing performance of the composite wires, as indicated by the increase in coercivity, decrease in magneto-impedance (MI) effect and decrease in sensitivity with increasing annealing temperature.
Simultaneous Electrodeposition of Multiple NiFe/Cu Composite Wires for Orthogonal Fluxgate Sensor

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The sensitivity of orthogonal fluxgate sensors was significantly enhanced when multiple sensing elements were used instead of a single sensing element, with the magnitude of the enhancement found to be dependent on the number of sensing elements used in the sensor. In this study, simultaneous electrodeposition of NiFe onto multiple 20 microns in diameter Cu wires was carried out. The electrodeposited wires were then embedded into epoxy resin to form multi-cores sensing elements. The results showed that simultaneous electrodeposition of NiFe/Cu composite did not result in any significant differences in the resulting composition and thickness of the deposited layer, as compared to single wire electrodeposition. The sensitivity of a sensing element with four composite wires was found to be about 2500 mV/Oe. This sensitivity is approximately three times that of a sensing element with one composite wire.
Micro Forming and Processing of Cu-based Amorphous Wires

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The original Cu-based amorphous wires were fabricated by in-rotating water quenching and glass coated Taylor techniques. With surface treatment, the diameter of the amorphous wire prepared by in-rotating water quenching will be more uniform, and the glass coated amorphous wires were put into hydrofluoric acid solution to remove the glass layer. The strength of the Cu$_{50}$Zr$_{46}$Al$_4$ amorphous wire is about 1800MPa. With drawing under different diamond dies, different diameters of Cu$_{50}$Zr$_{46}$Al$_4$ amorphous wires were obtained. And the surface changes induced by drawing, such as removing the flaws and increasing the surface residual stress, which affect the mechanical properties of the Cu-based amorphous wires.
Combining Full and Semi Closed Loop Synchronous Control for Dual Mechanically Coupled Ball Screw System

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Multiple feed drives and their control are widely used in manufacturing industry, such as the box-in-box structure and the gantry type systems. For such applications (typically the box-in-box), two drive units (a unit meaning a ball screw driven by a servomotor) are often arranged in parallel as one feed axis. Another feed axis then acts as the mechanical couple to bridge the two parallel drive units. For the two parallel drive units, accurate synchronous control is necessary to ensure good synchronization between them. However, some problems may rise in such a configuration. First, a noticeable synchronization error (i.e., the error between the two parallel drive units) may cause damage to the system hardware since the two units are mechanically coupled. Second, the pull-and-drag phenomenon likely occurs between the two units through the hard couple. Third, linear scales are often equipped for position feedbacks, but the cost will be increased for multiple axes. Therefore, this research analyzes the differences between the full closed-loop feedback control with linear scales and the semi-closed loop with encoders of servomotors. A hybrid control system is proposed which combines the advantages of the two structures (full and semi closed-loop) so that the defects mentioned above can be overcome. To establish the synchronous control system (dual parallel drive units, Fig. 1), a particular system identification approach is employed with a dynamic signal analyzer (Agilent 35670A) to obtain the mathematic model. The controller is then designed with PDFF (Pseudo Derivative Feedback Feedforward) control. The full and semi- closed-loop controls are analyzed and compared in terms of dynamic stiffness, position responses and steady-state errors. A new hybrid control scheme is then proposed for the investigated coupled system (Fig. 2). Experiments are conducted to verify the performance, which is also compared with other three conventional synchronous control schemes. The results show that the proposed approach has a much less pull-and-drag effect in comparison with the others. Also, the input torque voltages for the two parallel drive units have a better equality than the other cases. Finally, the positioning accuracy, as well as the synchronization error between the two units is satisfactory without using two linear scales (thus, reduce the cost).

Fig. 1 Investigated dual parallel drive units
Fig. 2 Proposed hybrid control scheme
A Network-Based Real-Time Control System for Mechanically-Coupled Multi-Axis Servomechanism

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The conventional analog control structure is currently the mainstream for automatic control systems, where the control commands or feedback signals are transferred in the format of analog signals. However, modern automation applications employ more and more devices which should communicate with either the central control units or other devices in the system. Hence, the entire system will become increasingly complex, and the difficulty in maintenance will also increase due to the overly complex wiring if conventional analog control is used. Also, the analog signals are easily interfered by environmental noise, which are extremely unfavorable to the development of large-scale automatic control systems. Therefore, the use of real-time network technology for control system construction becomes the trend of development to meet the requirements of large systems. This paper aims to develop a fully-digital and real-time network control architecture for development of large-scale automatic control systems. However, most of the manufacturers of automation related products develop their own network control techniques. This causes incompatibility for products of one another. Thus, the study aims to construct an open-structure and real-time PC-based control system based on SERCOS III (Fig. 1). The SERCOS III possesses the advantages such as the distributed control structure, fully digitized communication, high compatibility, excellent expandability and high signal transference speed, etc. In this paper, a multi-axis mechanically-coupled ball screw servomechanism is constructed (Fig. 2) and controlled with the SERCOS III network. For the control design, the mathematic model of the multi-axis mechanically-coupled platform is first identified. A fully-digitalized system identification approach is proposed, via which the model of the investigated coupled system is obtained. The controller is then designed based on the system model and the performance of the entire system is tested. The experimental results verified the accuracy of the model and thus the identification technique. The positioning ability and the synchronization among the multiple mechanically-coupled ball screws are also found to be satisfactory. Hence, it is concluded that with the network-based architecture, the system identification method and the control design have been successfully developed.
The Analysis of Geometric Dimension and Tolerance of Workpiece in Milling Process


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To meet the ever increasing demand for high part accuracy, it is always a challenge to be able to predict and control the dimensional and profile accuracy of the work piece especially in a finish milling process. The important factors influencing the final part dimension and shape error and their spread can be divided into four categories: thermal error, machine tool spatial errors, deflection of tool and workpiece due to cutting force, and tool runout. Compared with tool and work deflection, the magnitude of machine tool spatial error and tool runout are generally less significant in their contribution to the parts error in heavy cutting conditions. However, in the finishing cutting conditions, cutting force and temperature rise are much less than those in the heavy cutting conditions, the influences of the tool runout and the machine spatial errors become significant factors and need to be considered in analyzing the final part dimension and its variance. This paper establishes an analytical error model to investigate the effects of the mean and variance of the dynamic milling force, the tool runout and machine spatial error on the dimensional and geometric error and tolerance. Parallelism, roundness and profile of geometric tolerance, are discussed by combining the dimension and the dimensional spread of the machined parts. Experimental results show that the final part dimension and geometric tolerance in milling processes can be accurately predicted given the dynamic cutting force, tool runout, stiffness of tool and workpiece and the machine spatial error.

Keywords: part error model, milling process, geometric tolerance, milling force, dimension error.
Nanoporous anodic alumina oxide (AAO) templates are fabricated by anodizing method. The average diameters of nanoporous anodic alumina are 100 nm and 200 nm in this study. The nanostructures on the polymer thin films (PLA, PC) are fabricated by nanoimprint using AAO template. The molded plastic thin film for different processing parameters (imprinting temperature, imprinting pressure, imprinting time, de-molding temperature) is discussed on nanoimprint. The use of anodic aluminum oxide to prepare a mold insert for nanoimprint supports the formation of a nano-structure in the molded PC thin film, and effectively increases its reflectance. We used MG63 osteoblast-like cells cultured on the molded plastic thin film (PLA, PC) with nanostructure (the diameters of nanopillar are 100 nm, 200 nm), and the nanostructure of molded plastic thin film is observed cells by SEM. This study has shown that cell adhesion and activation can be influenced by surface topographic features with nanometer level, and the surface nanotopography can influence osteoblast-like cell behavior. The significant differences of cell proliferation and migration depend on nanopillars and nanoporous.
An Investigation of Vibration-Assisted Scribing Process for Brittle Materials

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Minimizing the crack of cutting groove and controlling the crack propagation are two of the most concerning issues in the scribing of brittle material. With the increasing demand for ever smaller line width, it has become a critical process capability to be able to cut silicon wafer of high density pattern while leaving the wafer free of crack. In this paper, we developed a tool motion control system with two orthogonal piezoelectric actuators to investigate the capability of the vibration-assisted scribing process. The motion control system is driven by sinusoidal voltages of fixed frequencies with 90 degree phase difference to generate an elliptical locus of the tool. The vibration-assisted scribing system comprises this elliptical tool motion and the linear motion of workpiece. In this study, the vibration amplitude along the cutting depth and the cutting velocity are selected as the process parameters to investigate the critical depth of cut (CDC) and the surface roughness of the groove and the results are compared with those of the traditional scribing process. The single crystal diamond and single crystalline silicon are selected as the tool and workpiece material, respectively. Experimental results show the maximum CDC is 1.8 μm in the vibration-assisted scribing, which is about ten times that of the tradition scribing process. Results in groove surface roughness measurement show that, in the brittle fracture region, the vibration-assisted scribing can reduce the crack propagation of groove bottom and achieve a smoother surface, and the surface roughness (Ra) in the ductile cutting region reaches about 0.08 ~ 0.10 μm.

Keywords: vibration-assisted scribing, brittle material, brittle-ductile transition depth, critical depth of cut (CDC)
A Hybrid Intelligent System for 3D Reconstruction from a Single Line Drawing

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In automatic reconstruction of 3D objects from single line drawings, existing systems are all single-track, containing one general solution for all drawings. Such a general system may not be able to produce the best solution for a drawing with certain dominant features, such as symmetry. This paper proposes a method in which an input drawing is first classified based on dominant features which may exist in the drawing, including symmetry, orthogonality and parallelism. The reconstruction is then performed by an algorithm which contains “experts” tuned to deal with each class specifically and effectively. Drawing classification is done using the technique of support vector machine classification. A specific set of features, also called “regularities”, are selected to form an optimal regularity set for each class, and used in the formulation of the objective function for effective reconstruction. Experimental results show that the proposed system can significantly improve the reconstruction accuracy and efficiency than that of a single-track general 3D reconstruction system.

Keywords: line drawings, reconstruction expert, regularities, support vector machine
Discussions of the Compliance Function in 3D Reconstruction from 2D line Drawings

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This study compares different forms of compliance function, such as the linear, polynomial and Gaussian forms, in 3D reconstruction of polyhedral objects, under the framework of support vector machine for regression (SVR). The correlations among different regularities are considered in the proposed form. We also calculate the corresponding coefficients of regularities based on a 2D line drawing library.

Keywords: 3D Reconstruction, Compliance function, Support vector machine, line drawings
Development of Engine Speed Sensor Test Bench

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As the electronic fuel injection (EFI) system of combustion engine is widely used in China, more and more components of EFI are demanded to be manufactured locally. Consequently, the requirements of test bench of EFI components from China local sensor suppliers are becoming more. The development of a test bench of signal wheel for electromagnetic engine speed sensor is described in this paper. Meanwhile, the structure and principle of signal wheel and electromagnetic engine speed sensor are introduced.

A new method is developed in this test bench by which the angle and wave form generated by the signal wheel can be measured automatically at the same time. Through the measured results, the manufacturing accuracy of the signal wheel can be checked. The entire measured datum are showed on screen and recorded by PC.

The structure and components of test bench such as mechanical design, electronic circuit, and control software are described in the paper meanwhile. The performance of the test bench is tested.
A Test System for PCU based on GPIB Interface with VB language

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Space power system play an important role in satellite, and power control unit (PCU) is the heart of the space power system. So it is more important to test the performance of PCU before equipped in satellite. A test system for PCU is described in this paper. Some Agilent powers are used to simulate the working environment of PCU, and how to control these simulators by software programmed by VB is described meanwhile.