CONFERENCE GUIDE

11th International Conference on Control, Automation, Robotics and Vision
(ICARCV 2010)

December 7-10, 2010
Grand Copthorne Waterfront Hotel Singapore
# TABLE OF CONTENTS

Welcome Messages............................................................................................................. 1
Committees.......................................................................................................................... 4
Information about Singapore................................................................................................. 6
General Conference Information.......................................................................................... 8
Conference Venue ................................................................................................................ 10
Floor Plan of Conference Venue.......................................................................................... 11
Keynote Addresses................................................................................................................ 13
Panel Sessions....................................................................................................................... 16
Technical Sessions & Abstracts............................................................................................. 21
Reviewers .............................................................................................................................. 132
Author Index ........................................................................................................................ 137
Program Overview .............................................................................................................. 148
MESSAGE FROM THE GENERAL CHAIR

Dear Friend and Colleagues,

On behalf of the organizing committee, we are pleased to welcome you to Singapore and to the 11th International Conference on Control, Automation, Robotics and Vision (ICARCV 2010)!

The biennial event of ICARCV has proven to be a premium forum for researchers and engineers from all around the world to share their latest research results and accelerating the exploitation of new technologies in Control, Automation, Robotics and Computer Vision. The organizing committee is extremely delighted to have received overwhelming worldwide responses for ICARCV 2010, and we are expected to host 400 delegates! The strong support from the Technical Program Committee has enabled us to put together a very solid technical program for the delegates. Besides the parallel technical sessions, there are also keynote addresses and panel discussions on the state-of-art development in Control, Automation, Robotics and Computer Vision to be delivered by eminent professors and researchers.

We are indeed honored to have Professor Minyue Fu from the University of Newcastle, Australia, Professor Bruno Siciliano from University of Naples Federico II, Italy and Professor Zhengyou Zhang from Microsoft Research, USA as the keynote speakers for ICARCV 2010. Their presence would undoubtedly act prestige to the conference as they are the giants in their respective fields. I would like to express my sincere appreciation to all the keynote speakers and panelists for their contributions and supports to ICARCV 2010.

I would like to thank all the organizers of invited sessions and the numerous researchers worldwide who helped to review the submitted papers. I am also grateful to the distinguished International Advisory Committee members for their invaluable supports and assistances. I would like to gladly acknowledge the technical sponsorship provided by the IEEE Control Systems Society, the IEEE Computational Intelligence Society and the IEEE Robotics and Automation Society. I also wish to place my hearty thanks to all the members of the Organizing Committee for their hard work to make this conference possible, and to many friends, colleagues and indeed family members who have helped the conference directly or indirectly. Last but not least, I am grateful for the strong and enthusiastic support of all delegates including many old faces from around the world.

I hope that you will find your participation in ICARCV 2010 stimulating, rewarding, enjoyable and memorable.

Changyun WEN
General Chair of ICARCV 2010
MESSAGE FROM THE TECHNICAL PROGRAM CHAIR

Dear friends and colleagues,

On behalf of the Technical Program Committee, we welcome you to the 11th International Conference on Control, Automation, Robotics and Vision (ICARCV 2010). The conference is a forum for scientists, engineers and practitioners throughout the world to present the latest advancement in Control, Automation, Robotics and Computer Vision. We have assembled an exciting Technical Program covering all topics in these areas.

We received a very good response to the Call for Papers with a total of 899 submissions including invited session papers from 56 countries/regions. All the submitted papers were processed by the Technical Program Committee which has 95 members who are well known researchers with vast professional experience in various areas of the conference. Ten to fifteen papers were assigned to each member. All the members worked professionally, responsibly and diligently in soliciting expert international reviewers. Besides evaluations from reviewers, each member also provided his/her own assessments on the papers assigned, so as to ensure that only high quality papers would be accepted. After going through such a rigorous reviewing process, we finally included 329 papers for presentation in 59 oral sessions and 106 papers in 3 poster sessions in the Technical Program. These papers contain the State-of-the-Art research results in both theory and applications in the areas of control, automation, robotics and computer vision. In addition, the Technical Program also includes 3 excellent keynote addresses and 2 panel sessions. The 3 keynotes are

**Audio-Visual Joint Processing for Active Object Detection**
by Professor Zhengyou Zhang, Microsoft Research, USA
09:15, Wednesday, December 8, 2010

**Network based Control and Estimation Problems**
by Professor Minyue Fu, The University of Newcastle, Australia
08:30, Thursday, December 9, 2010

**Robots Moving Closer to Humans**
by Professor Bruno Siciliano, University of Naples Federico II, Italy
08:30, Friday, December 10, 2010
The details of the 2 plenary panel sessions are

**Panel Session 1: Imaging and Vision: Challenges and Opportunities**

**Time:** 13:30-15:30, Wednesday, 8 December 2010  
**Panelists:**  
Professor Zhi-Qiang Liu, City University of Hong Kong, SAR, China  
Professor Brian Lovell, University of Queensland, Australia  
Professor Massimo Tistarelli, University of Sassari, Italy  
Professor Zhengyou Zhang, Microsoft Research (MSR), USA

**Panel Session 2: Control and Autonomy: Challenges and Opportunities**

**Time:** 13:10 - 15:10, Thursday, 9 December 2010  
**Panelists:**  
Professor Pedro Albertos, Polytechnic University of Valencia, Spain  
Professor Patrick Doherty, Linkoping University, Sweden  
Professor Minyue Fu, The University of Newcastle, Australia  
Professor Daniela Rus, MIT, USA  
Professor Bruno Siciliano, University of Naples Federico II, Italy

As in the past ICARCV conferences, we will present the Best Paper Award during the Conference. Based on reviewers’ comments and also the recommendation from TPC members, 14 papers were nominated for the best paper award. These 14 papers were further evaluated by some of our distinguished members of the International Advisory Committee to shortlist six finalists. The Best Paper will then be chosen by the Best Paper Selection Committee after further assessment of the oral presentations of the six finalists during the conference. The selection of the best paper is based on technical quality and presentations including both written and oral presentations. The Best Paper Award will be announced and presented during the Conference Banquet.

A CD-ROM containing preprints of all the papers scheduled in the program is provided at the conference to each registered participant as part of the registration package. The official conference proceedings will be published by IEEE and included in the IEEE Xplore Database.

On behalf of the Technical Program Committee, we would like to thank all our reviewers for their expert reviews which are invaluable to the Committee in making a fair decision on acceptance/rejection of each paper. We are also grateful to the distinguished International Advisory Committee members for their invaluable support and assistance. Thanks also go to the dedication, diligence and commitments of the Invited Session Chairs Professors Chien Chern Cheah, Eric Sung and Lihua Xie and all the members of the Technical Program Committee. We also wish to place our hearty thanks to many friends, colleagues and indeed family members who have helped completing the technical program directly or indirectly.

Thank you for your active participation of the conference. I hope that you will find your participation in ICARCV 2010 in Singapore stimulating, rewarding, enjoyable and memorable.

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P. N. Suganthan  
Technical Program Chairman, ICARCV 2010
COMMITTEES

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Advisor
Danwei WANG

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Lewis, Frank L (USA)

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Ortega, Romeo (France)

Pal, Nikhil R (India)

Parent, Michel (France)

Polycarpou, Marios M (Cyprus)

Siciliano, Bruno (Italy)

Slotine, Jean-Jacques E (USA)

Wang, Danwei (Singapore)

Zurada, Jacek. M. (USA)

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Ding, Zhengtao (United Kingdom)
Doherty, Patrick (Sweden)
Fan, Huijin (China)

Fang, Debin (China)
Gao, Huijun (China)
George, Koshy (India)
Gravdahl, Jan Tommy (Norway)
Guo, Yi (United States)
Hou, Saing Paul (Singapore)
He, Bo (China)
He, Ming-Yi (China)
He, Xiangjian (Australia)
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Huang, Hesheng (China)
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Karimwala, Vinay Kumar (Singapore)  Sluzek, Andrzej (Singapore)
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Khoo, Suiyang (Australia)  Song, Wenbin (China)
Kodagoda, Sarath (Australia)  Sree, KIRAN (India)
Koh, Tong San (Singapore)  Su, Chun-Yi (Canada)
Kumar, Ganesh (India)  Su, Weizhou (China)
Lam, Kenneth K.M (Hong Kong)  Sun, Dong (Hong Kong)
Lanusse, Patrick (France)  Sung, Eric (Singapore)
Lee, Peng Hin (Singapore)  Tahara, Kenji (Japan)
Lee, Tae-Eog (Korea)  Takemura, Hiroshi (Japan)
Li, Ning (China)  Tan, Tele (Australia)
Li, Yangmin (Macau, China)  Toh, Kar Ann (Korea)
Li, Yunhua (China)  Tsai, Ching-Chih (Taiwan)
Lin, Zongli (United States)  Ucinski, Dariusz (Poland)
Ling, Keck Voon (Singapore)  Wan, Shuai (China)
Liu, Chao (France)  Wang, Liuping (Australia)
Liu, Yungang (China)  Wang, Qing-Guo (Singapore)
Low, Kay Soon (Singapore)  Wang, X (China)
Ma, Xudong (China)  Wang, Yanwu (China)
Machado, J A Tenreiro (Portugal)  Wei, Baoguo (China)
Manic, Milos (United States)  Xia, Yuanqing (China)
Mao, Kezhi (Singapore)  Xie, Lihua (Singapore)
Martinet, Philippe (France)  Yang, Guilin (Singapore)
Mckenna, Stephen (United Kingdom)  Yau, Wei Yun (Singapore)
Nagata, Fusaomi (Japan)  Yuen, Pong C (Hong Kong)
Phat, Vu Ngoc (Vietnam)  Zhang, Chengjin (China)
Prabu, D (India)  Zhang, Weihai (China)
Qin, Shi-Yin (China)  Zhou, Junhong (Singapore)
Ramalingam, Soodamani (United Kingdom)  Zou, Yun (China)
Roopaei, Mehdi (Iran)  

**Technical & Logistics Support Committee**
Tan, Peng Chye  Chia, Chiu Kiat
Lim, Puay Chye  Sow, Peck Heng
Yock, Ching Fong  Neo, Kok Chuan
Tan, Chai Soon  Ziauddin, Mohamed
Ng-Yap, Poh Geok, Pamela  

**Conference Secretariat**
Tan, Peng Chye  
Nanyang Technological University  
School of Electrical and Electronic Engineering  
Singapore 639798  
Tel: (65) 6790 4220  
E-mail: icarcv@ntu.edu.sg
INFORMATION ABOUT SINGAPORE

Singapore is a bustling cosmopolitan city populated with high-rise buildings and landscape gardens. Brimming with a harmonious blend of culture, cuisine, arts and architecture, Singapore is a dynamic city that’s rich in contrast and color. In fact, you can even say that Singapore embodies the finest of both East and West.

Located in Southeast Asia, Singapore has a land area of about 710 square kilometres, making her one of the smallest countries in the world and the smallest in the region – hence the moniker "The Little Red Dot". Although small in size, Singapore commands an enormous presence in the world today with its free trade economy and highly efficient workforce. Also, her strategic location in the region has enabled her to become a central sea port along major shipping routes.

People
At present, Singapore’s population stands at about five million people, with English as the main language of instruction, and a mother tongue for each major ethnicity. Coming together as a society and living in harmony, there are four major races – namely the Chinese (majority), Malay, Indian and Eurasian.

The ethnic Chinese form 74.2% of the Singaporean population, with the country’s original inhabitants – the Malays, comprising of 13.4%. The Indians make up 9.2%, and Eurasians, Peranakans and others making up a combined 3.2%. Singapore's many races live together in harmony, united by the motto, "Many races, one Singapore", and it is this ethnic diversity that is one of Singapore's strengths.

Each community offers a different perspective of life in Singapore in terms of culture, religion, food and language.

Language
The four official languages in Singapore’s constitution are English, Chinese, Malay and Tamil. However, in recognition of the status of the Malay people as the indigenous community in Singapore, the national language of the country is Bahasa Melayu, or the Malay Language.

The presence of other languages, especially the varieties of Malay and Chinese, has obviously had an influence on the type of English that is used in Singapore. The influence is especially apparent in informal English, an English-based creole that is commonly known as Singlish. A badge of identity for many Singaporeans, it represents a hybrid form of the language that includes words from Malay, as well as Chinese and Indian languages.

Sight Seeing
You can experience Singapore’s rich historical heritage by visiting many of the national monuments, museums and memorials located around the city. On your trip here, remember to take a walk along one of the many heritage trails and enjoy the sights and sounds at various cultural precincts, notably Chinatown, Little India and Kampong Glam or visit the well-known landmarks for a complete Singapore journey.

Shopping
If you prefer the bright city lights and being amidst the hustle and bustle, then you’ll be delighted to know that there are numerous shopping malls, museums, and dining and entertainment hotspots to choose from. Get into the thick of the shopping action at the iconic Orchard Road stretch, or party the night away at the Clarke Quay or Boat Quay areas, both of which offer a myriad selection of nightlife activities.

Cuisine
It would not be at all surprising if the phrase "eat to your heart's content" originated from New Asia - Singapore. The reason being, in Singapore’s multi-racial melting pot, all the various Asian cuisines compete in the battle of the taste buds: Malay, Chinese, Indonesian, Peranakan, Indian, Thai, Japanese and Korean. Adding to this delicious confusion is Singapore’s vast array of hawker stalls and restaurants that range from global franchises to gourmet delis to fancy six-star settings. And there are also the seemingly endless food promotions and food tours that run throughout the year,
including the Singapore Food Festival in July. Some of the local food includes Chicken Rice, Chilli Crab, Indian/Chinese Rojak, Laksa, Mee Rebus, Nasi Lemak and Roti Prata.

**Weather**

Singapore has a tropical climate with relatively uniform temperature all year round. Temperature ranges from a low of 24°C to a high of around 31°C every day, and relative humidity is high. Rainfall usually takes the form of sudden showers and storms, which pass quite quickly, although more prolonged periods of rain can be expected during the monsoon season from November to January.

**Transport**

Singapore has one of the best mass rapid transit systems in the world and the proposed convention venue is well within its reach. The nearest MRT stations to the conference venue are the Esplanade MRT (CC3) and Promenade MRT (CC4) along the Circle Line. Taxis are also readily available and are charged by metered fare. Please note that various surcharges are applicable, including for rides during peak hours (07:00 – 09:30, 17:00 – 20:00 hrs) and for booking of taxis. Guided tours by taxi with trained taxi drivers are also available at reasonable rates. In addition, if you choose to explore Singapore by bus, there is an excellent network of air-conditioned buses.

**More about Singapore**

To find out more about Singapore, please visit the website:
http://www.yoursingapore.com/content/traveller/en/browse/see-and-do.html

**Hours**

Most shops open from 10:00 to 22:00, including Sundays and Public Holidays. Some convenience stores such as 7-Eleven open 24 hours a day.

**Currency**

The local currency is the Singapore dollar. S$1.00 is about US$0.72 or Euro 0.59.

**Telephone**

Visitors may purchase overseas calling cards for inexpensive overseas calls. These can be purchased at convenience stores and post offices. Some useful telephone numbers are given below.

- Police: 999
- Ambulance: 995
- Fire-Brigade: 995
- Cab booking –
  - Comfort and CityCab: 6552 1111
  - TIBS and SMRT: 6555 8888
  - Premier (Silvercab): 6363 6888
GENERAL CONFERENCE INFORMATION

Organizer
- School of Electrical and Electronic Engineering, Nanyang Technological University

Technical Co-Sponsors
- IEEE Control Systems Society
- IEEE Computational Intelligence Society
- IEEE Robotics and Automation Society,

Language
The conference and all its activities will be conducted in English.

Registration
All delegates are required to register upon arrival. A conference kit will be given which will contain a copy of the CD-ROM proceedings and the Conference Guide. Each delegate will be given a name badge and it has to be worn at all times during the conference. Delegates/Accompanying Persons who have registered for the Conference Banquet will also be given tickets.

The registration hours are:
Tuesday  December 7  17:00 – 20:00  Level 2, Foyer of Waterfront Ballroom
Wednesday December 8  08:00 – 16:00  Level 4, Foyer of Grand Ballroom
Thursday  December 9  08:00 – 14:00  Level 4, Foyer of Grand Ballroom
Friday    December 10 08.00 – 12:00  Level 4, Foyer of Grand Ballroom

Registration Fee
IEEE Members  $950
Non-members   $1100

The Conference Registration Fee includes one welcome reception, six tea-breaks, three lunches, one conference banquet and one copy of the CD-ROM Proceedings.

Additional banquet ticket can be purchased at SGD100 per person.

Oral Presentation
1. Please note that the time allocated to each oral presentation is 20 minutes. 15 minutes on Presentation and 5 minutes for Q&A.
2. Surrogate presenters are expected to be sufficiently familiar with the material being presented to answer questions from the audience and inform the Session Chair before the start of the session that he/she will be presenting on behalf of the co-author(s).
3. Microsoft PowerPoint slides or Acrobat PDF for presentation on a LCD video projector is recommended.
4. All the presentation rooms will be equipped with a computer running Windows XP operating system, installed with Microsoft Office 2003 compatible plus Acrobat Reader version 7 compatible and a LCD video projector.
5. Authors are advised to prepare their presentation files in a format compatible with one of the above applications, with the files stored in a CD-ROM or a USB flash drive. Please
ensure that there is no virus in the USB flash drive.
6. For authors using Mac computers, please ensure that your presentation file is compatible with that mentioned in Item 4 above.
7. Presentation files should be up-loaded into the computer in the assigned presentation room 10 minutes before the start of your scheduled session. There will be an assistant in the room to help you.

**Poster Presentation**
The poster session will be held at the Foyer on Level 4.
1. Authors will be provided with one A0 size (1189 x 841 mm) poster stand.
2. Authors may prepare their own presentation in one A0 size paper or a few A4 size papers to be pasted on the poster stand.
3. Authors may select their own design layout, colors and contents within the frame. However, the poster must be in Portrait orientation.
4. Authors are asked to report to the person in-charge at the Foyer by 8.15 am.
5. Posters will be displayed until 6pm. However, the authors are expected to be present near their display during the morning and afternoon tea breaks.

**Welcome Reception**
A Welcome Reception will be held on Tuesday, 7 December 7 between 6.00 to 8.00 pm at the Foyer of Waterfront Ballroom, Level 2, Grand Copthorne Waterfront Hotel.

**Cocktail Reception cum Conference Banquet**
The cocktail reception will be held on Thursday, December 9, 2010 at 7.00 pm in the Grand Ballroom Foyer, Level 4, Grand Copthorne Waterfront Hotel. The banquet will commence at 7.30 pm. Additional tickets at S$100 can be purchased from the Secretariat.

**Internet Access**
Complimentary internet access will be provided at the Secretariat Room, Toucan Room, Level 4. Please limit your access to 15 minutes. In addition, wireless internet access will also be available at the conference and access instructions will be provided during the registration.
Kim Seng Road (Grand Copthorne Waterfront Hotel)

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Zion Road (Food Centre)

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Havelock Road (Riverview Hotel)

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Havelock Road (Copthorne King’s Hotel)

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- Pre-Conference Registration at Foyer of Waterfront Ballroom on 7th December
- Welcome Reception at Foyer of Waterfront Ballroom on 7th December
- Lunches on 8th to 10th of December at Waterfront Ballroom
Opening Ceremony, Keynote Sessions, Panel Sessions at Grand Ballroom
- Oral Sessions at Grand Ballroom, Canary I/II, Kingfisher, Nightingale, Pelican, Oriole and Bluebird
- Tea-breaks, Interactive Sessions at Foyer
- Secretariat Room at Toucan Room
Audio-Visual Joint Processing for Active Object Detection

Professor Zhengyou ZHANG
Microsoft Research
USA

Wednesday, December 8, 2010
09:15 – 10:15
Grand Ballroom, Level 4

Abstract: Active object detection is very important in many applications including robot navigation. Interaction with the dynamic surrounding environment by a human being or a robot is inherently multimodal, and two dominant modalities are, without question, audio and visual. In this keynote, I will describe some of our recent activities in audio-visual processing for active object detection and show that multimodal fusion provides significant improvement in robustness and accuracy over the case when audio and video are processed independently. Applications include: presence detection in an office environment using multi-sensory inputs from streams of video, audio, and mouse and keyboard events; active speaker detection in a meeting room using microphone arrays and camera arrays; speaker recognition from face images and audio signals.

Biography: Zhengyou Zhang is a Principal Researcher at Microsoft Research (MSR), the research center of Microsoft Corp. and is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE). He is the Founding Editor-in-Chief of the newly established IEEE Transactions on Autonomous Mental Development (IEEE T-AMD), and is on the Editorial Board of the International Journal of Computer Vision (IJCV), the IEEE Transactions on Multimedia (IEEE T-MM), the International Journal of Pattern Recognition and Artificial Intelligence (IJPRAI), and the Machine Vision and Applications. He was on the Editorial Board of the IEEE Transactions on Pattern Analysis and Machine Intelligence (IEEE T-PAMI) from 1999 to 2004. He is listed in Who's Who in the World, Who's Who in America and Who's Who in Science and Engineering.
Network based Control and Estimation Problems

Professor Minyue FU
University of Newcastle, Callaghan
Australia

Thursday, December 9, 2010
08:30 – 09:30
Grand Ballroom, Level 4

Abstract: Rapid advances in communications, networking and sensing technologies have enabled wide deployment of networked control systems, with applications ranging from automated traffic networks to mobile sensor networks and unmanned airborne vehicles. This is an area of research with many new theoretical and technological challenges and requires multi-disciplinary collaborations. This talk will provide an overview of this emerging area and highlight some key research opportunities and challenges from the control point of view. We will start with motivational examples in wireless industrial control networks and smart power networks and study the associated control and estimation problems in these two applications. We then discuss several new theoretical results on networked control and estimation, including quantized LQG control, quantized state estimation, state estimation with packet dropouts; network-based consensus and network-based system identification.

Biography: Professor Minyue Fu received his Bachelor's Degree in Electrical Engineering from the University of Science and Technology of China, Hefei, China, in 1982, and M.S. and Ph.D. degrees in Electrical Engineering from the University of Wisconsin-Madison in 1983 and 1987, respectively. From 1987 to 1989, he served as an Assistant Professor in the Department of Electrical and Computer Engineering, Wayne State University, Detroit, Michigan. He joined the Department of Electrical and Computer Engineering, the University of Newcastle, Australia, in 1989. Currently, he is a Chair Professor in Electrical Engineering. In addition, he was a Visiting Associate Professor at University of Iowa in 1995-1996, and a Senior Fellow/Visiting Professor at Nanyang Technological University, Singapore, 2002. He holds a Changjiang Visiting Professorship at Shandong University and a Qian-ren Professorship at Zhejiang University in China.

He is a Fellow of IEEE. His main research interests include control systems, signal processing and communications. He has been an Associate Editor for the IEEE Transactions on Automatic Control, Automatica and Journal of Optimization and Engineering.
KEYNOTE ADDRESS III

Robots Moving Closer to Humans

Professor Bruno SICILIANO
University of Naples Federico II
Italy

Friday, December 10, 2010
08:30 – 09:30
Grand Ballroom, Level 4

Abstract: Robots! Robots on Mars and in oceans, in hospitals and homes, in factories and schools, robots fighting fires, making goods and products, saving time and lives. Robots today are making a considerable impact on many aspects of modern life, from manufacturing to healthcare. Reaching for the human frontier, robotics is also vigorously engaged in the growing challenges of new emerging domains. Interacting, exploring, and working with humans, the new generation of robots will increasingly touch people’s lives. Unlike the industrial robotics domain where the workspace of machines and humans can be segmented, applications of intelligent machines that work in contact with humans are increasing, which involve e.g. haptic interfaces and teleoperators, cooperative material-handling, power extenders and such high-volume markets as rehabilitation, physical training, entertainment. In this context, it is customary to distinguish between Cognitive Human-Robot Interaction (cHRI) and Physical Human-Robot Interaction (pHRI). This talk is aimed at discussing a number of issues in pHRI concerning with safety, dependability and dexterity. The presentation will be accompanied by videos illustrating experimental tests on both conventional and new lightweight robots endowed with force and vision sensors.

Biography: Bruno Siciliano is Professor of Control and Robotics, and Director of the PRISMA Lab in the Department of Computer and Systems Engineering at University of Naples Federico II. His research interests include force and visual control, human-robot interaction and service robotics. He has co-authored 7 books, 70 journal papers, 170 conference papers and book chapters. He has delivered 80 invited lectures and seminars at institutions worldwide. He is a Fellow of IEEE, ASME and IFAC. He is Co-Editor of the Springer Tracts in Advanced Robotics, and of the Springer Handbook of Robotics, which recently received the PROSE Award for Excellence in Physical Sciences & Mathematics and was also the winner in the category Engineering & Technology. Professor Siciliano is the Past-President of the IEEE Robotics and Automation Society.
ICARCV 2010 proudly presents a plenary panel session on ‘Imaging and Vision: Challenges and Opportunities’. We are honored to be able to host four prominent professors in the fields of imaging and vision to be the panelists. The objective of the plenary panel session is to provide an opportunity for researchers, especially early career researchers, to interact with world renowned experts in imaging and vision and seek their views on current and possible future developments of these fields. During the session, panel members will share their vast experiences and visions with audience through effective face-to-face dialogues.

The panel consists of four world class researchers and educators. They are:

Professor Liu, Zhi-Qiang has worked in both academic and industry for over 30 years. He has taught in three Universities in Canada, the University of Melbourne, Australia, and City University of Hong Kong, SAR, China. He is currently with the School of Creative Media, City University of Hong Kong. He has taught many courses such as Art and Technology, Digital Media, Computer Graphics, Animation with Blender; Computer Architecture, Computer Networks, Artificial Intelligence, C programming language, Machine Learning, and Pattern Recognition and supervised many software development projects in media art and media technology.

However, in order not to be swayed by vanity and to focus on academic matters and be able to express freely as a teacher, in principle Professor Liu doesn't join any professional associations, hence saving the dues and time, but offers his service when needed by the community. Professor Liu has been a Panel member in Research Grants Council, UGC Hong Kong for seven years. He serves on the boards of Hong Kong Innovation and Technology Commission (ITC), Hong Kong Cyberport IncueTrain Advisory Committee and IncueTrain Vetting Committee.
Self-Validated Labeling of Markov Random Fields in Computer Vision by Professor Liu

In computer vision a large number of problems is about finding boundaries in a scene which are usually ill-defined due to lack of resolution, noise and occlusions, etc. Traditional approaches such as regularization and the well-known Laplacian of Gaussian (LoG) type filters throughout the 70s to early 90s have not led to satisfactory results. We have found, however, combining with unsupervised learning, more specifically, clustering, with the theory of Markov Random Field (MRF) we are able to achieve marked improvements over some of the major techniques recently reported in the literature. In this talk I will address in particular the problem of self-validated labeling of Markov random fields (MRFs), namely to optimize an MRF with unknown number of labels. We present graduated graph cuts (GGC), a new technique that extends the binary s-t graph cut for self-validated labeling. Specifically, we use the split-and merge strategy to decompose the complex problem to a series of tractable subproblems. In terms of Gibbs energy minimization, a suboptimal labeling is gradually obtained based upon a set of cluster-level operations. By using different optimization structures, we propose three practical algorithms: tree-structured graph cuts (TSGC), net-structured graph cuts (NSGC) and hierarchical graph cuts (HGC). In contrast to previous methods, the proposed algorithms can automatically determine the number of labels, properly balance the labeling accuracy, spatial coherence and the labeling cost (i.e., the number of labels), and are computationally efficient, independent to initialization and able to converge to good local minima. We apply the proposed algorithms to natural image segmentation. Experimental results show that our algorithms produce generally feasible segmentations for Benchmark datasets, and outperform alternative methods in terms of robustness to noise, speed and preservation of soft boundaries.

Professor Brian C. Lovell was born in Brisbane, Australia in 1960. He received the BE in electrical engineering (Honours I) in 1982, the BSc in computer science in 1983, and the PhD in signal processing in 1991: all from the University of Queensland (UQ). Professor Lovell is Project Leader of the Advanced Surveillance Group in NICTA and Research Leader of the Security and Surveillance Group in the School of ITEE, UQ. He served as President of the International Association of Pattern Recognition 2008-2010, and is a Senior Member of the IEEE, Fellow of the IEAust, and voting member for Australia on the Governing Board of the International Association for Pattern Recognition since 1998. Professor Lovell was Program Co-Chair of ICPR2008 in Tampa, Florida, and is General Co-Chair of ACPR2011 in Beijing, and ICIP2013 in Melbourne. The Advanced Surveillance Group works with port, rail, and airport organizations as well as several national and international agencies to identify and develop technology-based solutions to address real operational and security concerns.

Advanced Surveillance to Protect Critical Infrastructure, by Professor Lovell

In this talk recent trends in modern surveillance networks will be discussed including topics such as super-megapixel cameras, post incident digital PTZ, integration and fusion of video and non-video sensors, and multimodal remote biometrics including face and iris on the move. Current projects underway with port, rail, and local councils will be outlined in brief. Finally there will be video demonstrations of NICTA low-resolution face search technologies.

Professor Massimo Tistarelli was born on November 11, 1962 in Genoa, Italy. He received the Phd in Computer Science and Robotics in 1991 from the University of Genoa, Massimo Tistarelli is currently Full Professor in Computer Science and director of the Computer Vision Laboratory at the University of Sassari, Italy. Since 1986 he has been involved as project coordinator and task manager in several projects on computer vision and biometrics funded by the European Community. He is a founding member of the Biosecure Foundation, which includes all major European research centers working in biometrics.

His main research interests cover biological and artificial vision, biometrics, robotic navigation and visuo-motor coordination. He is co-author of more than 100 papers in scientific conferences, books and international journals. Prof. Tistarelli is the principal editor for the Springer book "Handbook of Remote Biometrics", published in June 2009. He holds an international patent for an automatic biometric system based on face modality (Int.l Patent G06K9/62 EU Patent G06K9/00F3;
He also firstly proposed a unique, advanced method for the integration of face and fingerprint modalities already at the feature level. In 1991 he was awarded the best paper award from IEEE Computer Society.

Since 1998 he was the chairman for several International scientific events on biometrics. He was the chairman of the 5th IEEE AutoID conference, track chair for biometrics at the 19th ICPR, Area chair for CVPR 2010 and general chair of the IEE/IAPR 3rd Int.1 Conference on Biometrics held in June 2009. Prof. Tistarelli is associate editor for the journals IEEE Transactions on Pattern Analysis and Machine Intelligence, Image and Vision Computing and Pattern Recognition. Since 2003 he is the founding director for the Int.1 Summer School on Biometrics (now at the 8th edition). He is the chair of the IAPR Technical Committee 4 on biometrics, President of the IEEE Biometrics chapter, Member of the IEEE Biometrics Professional Certification Committee, Fellow member of IAPR and Senior member of IEEE.

The state of the art, opportunities and challenges in face-based biometrics

Enrolling to a graduation course and crossing the Singapore border may seem two very different tasks. Yet they share a fundamental common operation: the verification of the user identity. Due to a variety of reasons ranging from the need of an increased security to the need to facilitate the access to e-services, the process of identification requires a fast, easy and secure process. Among the available identification technologies biometrics, and in particular face recognition, has grabbed the attention of several sectors in our society.

Despite the sometimes good or bad advertisement of these technologies, the identification of people’s faces is a reality which is now possible thanks to a number of technologies, first of all Computer Vision and Image Understanding. The human face may seem to be a simple object to be recognized. After all we learn to recognize faces since birth. Yet, faces are quite complex objects: they have no fixed geometry, they do change their shape over time, the colour is not constant, the face appearance may change due to different pose and illumination. These, as well as other peculiarities of human faces are still a real challenge for many computer vision and machine learning algorithms applied for the identification of human faces. The fact that several face recognition algorithms have been devised and successfully tested, and a number of commercial face recognition systems are now on the market, is a proof that this is a mature and very promising technology. Moreover, this demonstrates the efficacy and success of Computer Vision research pursued over the past 40 years.

Faces are intrinsically 3D objects. As a consequence, the analysis of 2D face images to infer useful information about the imaged subject is an ill-posed problem. It can be overcome either by fusing multiple images (to indirectly infer the missing information due to the 3D to 2D transformation) or by directly measuring the 3D face shape. Either using 2D or 3D information can lead to interesting considerations about the face structure. Moreover, 2D (textural) and 3D (geometrical) data can be combined to improve the identification accuracy.

Several applications domain demonstrate how promising this technology is. From forensic practice to e-government, the analysis and identification of human faces constitutes a real challenge which current technologies based on Computer Vision research are ready to face.

Professor Zhengyou Zhang is a Principal Researcher at Microsoft Research (MSR), the research center of Microsoft Corp. and is a Fellow of the Institute of Electrical and Electronic Engineers (IEEE). He is the Founding Editor-in-Chief of the newly established IEEE Transactions on Autonomous Mental Development (IEEE T-AMD), and is on the Editorial Board of the International Journal of Computer Vision (IJCV), the IEEE Transactions on Multimedia (IEEE T-MM), the International Journal of Pattern Recognition and Artificial Intelligence (IJPRAI), and the Machine Vision and Applications. He was on the Editorial Board of the IEEE Transactions on Pattern Analysis and Machine Intelligence (IEEE T-PAMI) from 1999 to 2004. He is listed in Who's Who in the World, Who's Who in America and Who's Who in Science and Engineering. http://research.microsoft.com/~zhang/.

Opportunities and challenges of depth camera, by Professor Zhang

With the launch of Microsoft Kinect sensors for Xbox 360, depth cameras are expected to become affordable for the vision and robotics communities because the mass game market will drive the cost down. This could present a revolution in our research. I will talk about the opportunities and challenges accompanying the wide availability of depth cameras.
PANEL SESSION II

Control and Autonomy: Challenges and Opportunities

Time: 13:10 – 15:10, December 9, 2010
Venue: Grand Ball Room, Level 4
Chair: Professor Yeng Chai SOH, Nanyang Technological University, Singapore

Panelists: Professor Pedro ALBERTOS, Polytechnic University of Valencia, Spain
Professor Patrick DOHERTY, Linkoping University, Sweden
Professor Minyue FU, The University of Newcastle, Australia
Professor Daniela RUS, MIT, USA
Professor Bruno SICILIANO, University of Naples Federico II, Italy

ICARCV 2010 proudly presents the plenary panel session on Control and Autonomy: Challenges and Opportunities. We are honored to be able to invite five prominent professors in the field of control and robotics to be the panelists. The objective of the plenary panel session is to provide an opportunity for researchers, especially young researchers, to interact with world renowned experts in control and autonomy and seek their views on current and possible future developments of the fields. During the session, panel members will share their vast experiences and visions with audience through effective face-to-face dialogues.

The panel consists of five world class researchers and educators. They include:

Professor Pedro Albertos, past president of IFAC (the International Federation of Automatic Control) in 1999-2002, and Senior Member of IEEE, is a world recognized expert in real-time control, leading several projects in the field. Full Professor since 1975, he is currently at Systems Engineering and Control Dept. UPV, Spain. He is Doctor Honoris-Causa from Oulu University (Finland) and Bucharest Polytechnic (Rumania). Invited Professor in more than 20 Universities, he delivered seminars in more than 30 universities and research centres. Authored over 300 papers, book chapters and congress communications, co-editor of 7 books and co-author of “Multivariable Control Systems” (Springer 2004) and “Feedback and Control for Everyone”(Springer 2010), he is also associated editor of Control Engineering Practice and Automatica and Editor in Chief of the Spanish journal RIAI. His research interest includes multivariable control and nonconventional sampling control systems, with focus on time delays and multirate sampling patterns.

Professor Patrick Doherty is a Professor of Computer Science at the Department of Computer and Information Sciences (IDA), Linkoping University, Sweden. He heads the Artificial Intelligence and Integrated Computer Systems Division at IDA. He serves as director of LinkLab, a research center for future aviation systems, which is a collaborative endeavor between Linkoping University and Saab Aero Systems. He is an ECCAI fellow and currently an ECCAI board member. He has previously served as president of SAIS, the Swedish Artificial Intelligence Society. He is an associate editor for the Artificial Intelligence Journal and is on the board of directors for KR Inc. His main areas of interest are knowledge representation, automated planning, intelligent autonomous systems and multi-agent systems. A major area of application is with Unmanned Aircraft Systems. His research group has successfully designed and deployed many autonomous UAV systems in the past decade have also won several international competitions pertaining to micro-aerial vehicles and to automated planning. He has over 150 refereed scientific publications in his areas of expertise and has given many keynote and invited talks at leading international conferences. He is also CEO of a new start-up company, UAS Technologies Sweden AB, which designs and markets Micro-Aerial Vehicles.
**Professor Minyue Fu** received his Bachelor's Degree in Electrical Engineering from the University of Science and Technology of China, Hefei, China, in 1982, and M.S. and Ph.D. degrees in Electrical Engineering from the University of Wisconsin-Madison in 1983 and 1987, respectively. From 1987 to 1989, he served as an Assistant Professor in the Department of Electrical and Computer Engineering, Wayne State University, Detroit, Michigan. He joined the Department of Electrical and Computer Engineering, the University of Newcastle, Australia, in 1989. Currently, he is a Chair Professor in Electrical Engineering. In addition, he was a Visiting Associate Professor at University of Iowa in 1995-1996, and a Senior Fellow/Visiting Professor at Nanyang Technological University, Singapore, 2002. He holds a ChangJiang Visiting Professorship at Shandong University and a Qian-ren Professorship at Zhejiang University in China.

He is a Fellow of IEEE. His main research interests include control systems, signal processing and communications. He has been an Associate Editor for the IEEE Transactions on Automatic Control, Automatica and Journal of Optimization and Engineering.

**Professor Daniela Rus** is a Professor of Electrical Engineering and Computer Science, where she is associate director of MIT's Computer Science and Artificial Intelligence Lab (CSAIL) and co-directs the MIT Center for Robotics at CSAIL. Her research interests include distributed robotics and mobile computing and her application focus includes transportation, security, environmental modeling and monitoring, underwater exploration, and agriculture.

Rus is notable for spear-heading research in programmable matter by developing the several self-configuring robots. In addition, she worked with her students to has designed, control, and field autonomous underwater robots, agricultural robots that herd cattle, low-cost, early warning sensors for disaster prevention in developing countries, and teams of autonomour aerial vehicles that can monitor adaptively large environments.

Rus is the recipient of the NSF Career Award and an Alfred P. Sloan Foundation Fellow. She is a Class of 2002 MacArthur Fellow and a fellow of AAAI and IEEE. Before receiving her appointment at MIT, Rus was a professor in the Computer Science Department at Dartmouth, where she founded and directed two laboratories in robotics and mobile computing.

Rus earned her PhD in Computer Science from Cornell University.

**Professor Bruno SICILIANO** is Professor of Control and Robotics, and Director of the PRISMA Lab in the Department of Computer and Systems Engineering at University of Naples Federico II. His research interests include force and visual control, human-robot interaction and service robotics. He has co-authored 7 books, 70 journal papers, 170 conference papers and book chapters. He has delivered 80 invited lectures and seminars at institutions worldwide. He is a Fellow of IEEE, ASME and IFAC. He is Co-Editor of the Springer Tracts in Advanced Robotics, and of the Springer Handbook of Robotics, which recently received the PROSE Award for Excellence in Physical Sciences & Mathematics and was also the winner in the category Engineering & Technology.

Professor Siciliano is the Past-President of the IEEE Robotics and Automation Society.
Detailed Technical Session Listing and Abstracts
Session WA1 - Invited Session
Date: Wednesday, 08 December 2010
Time: 1040 - 1200
Venue: Ball Room

Advances in Biometric Theory and Applications I
Chairs: Wei Yun YAU
Institute for Infocomm Research

WA1.1 P1143 1040 - 1100
Sparse Representations and Random Projections for Robust and Cancelable Biometrics
Vishal M PATEL, Rama CHELLAPPA, *Massimo TISTARELLI
University of Maryland
*University of Sassari

In recent years, the theories of Sparse Representation (SR) and Compressed Sensing (CS) have emerged as powerful tools for efficiently processing data in non-traditional ways. An area of promise for these theories is biometric identification. In this paper, we review the role of sparse representation and CS for efficient biometric identification. Algorithms to perform identification from face and iris data are reviewed. By applying Random Projections it is possible to purposively hide the biometric data within a template. This procedure can be effectively employed for securing and protecting personal biometric data against theft. Some of the most compelling challenges and issues that confront research in biometrics using sparse representations and CS are also addressed.

WA1.2 P1124 1100 - 1120
Generating Cancelable Biometric Templates using a Projection Line
Tohari AHMAD, Jiankun HU
RMIT University

Biometric authentication systems can address the problems of genuine user verification and usability suffered by the conventional cryptosystems based on the password and token. However, as biometrics is not replaceable, its privacy has become a concern. Also, if the same biometrics is used in multiple applications, it will be vulnerable to potential cross-matching attacks. In this paper, a projection line method is proposed for cancelable fingerprint template design. The main advantage of this method is its simplicity. Because there exist many possibilities projecting minutiae into the projection line controlled by the whole range of possible projection line properties, the proposed approach offers non-invertible transformation and also possess good revocability property.

WA1.3 P1137 1120 - 1140
A Pitfall in Fingerprint Features Extraction
Peng ZHANG, Cai LI, Jiankun HU
RMIT University

In fingerprint feature extraction, it is perceived that pixel-level image rotation transformation is a lossless transformation process. In this paper, investigation has been conducted on analyzing the underlying mechanisms of fingerprint image rotation processing and potential effect on the major features, mainly minutiae and singular point, of the rotation transformed fingerprint. Qualitative and quantitative analysis have been provided based on the intensive experiments. It is observed that the information integrity of the original fingerprint image can be significantly compromised by the image rotation transformation process, which can cause noticeable singular point change and produce non-negligible number of fake minutiae. It is found that the quantization and interpolation process can change the fingerprint features significantly though they may not change the image visually.

WA1.4 P1146 1140 - 1200
MCC: A Baseline Algorithm for Fingerprint Verification in FVC-onGoing
Raffaele CAPPELLI, Matteo FERRARA, Davide MALTONI
University of Bologna

This paper describes an improved version of the MCC fingerprint matching approach. An in-depth error analysis allowed us to point out the weakest points of the original MCC and to design: i) a more effective minutiae pair selection and ii) a more distortion-tolerant relaxation. The parameters of the new version have been tuned over a new larger dataset and the final algorithm has been evaluated on FVC-onGoing. The results show that MCC compares favorably with some of the most accurate commercial algorithms published in FVC-onGoing.
Session WA2

Date: Wednesday, 08 December 2010
Time: 1040 - 1220
Venue: Canary I

Neuro-Fuzzy Control I

Chairs: Sundararajan NARASIMHAN
Nanyang Technological University
Xiaolin ZHANG
Tokyo Institute of Technology

WA2.1 P0332 1040 - 1100
Globally Exponential Stability of Delayed Neural Networks with Impulses
Jin ZHOU, *Quanjun WU, Lan XIANG, **Gang ZHANG
Shanghai University
*University of Electric Power, Shanghai
**Hebei Normal University

The present paper is mainly concerned with the issues of global exponential stability in recurrent delayed neural networks in the presence of impulsive connectivity between the neurons. By establishing an extended Halanay differential inequality on impulsive delayed neural networks, some simple yet generic criteria for global exponential stability of such neural networks are derived analytically. Compared with some existing works, the distinctive feature of these criteria is that it is not necessary to learn the priori information about the stability of the corresponding neural networks without impulses, which means the recurrent delayed neural networks can be globally exponentially stabilized by impulses even if the corresponding neural networks without impulses may be unstable or chaotic itself. Moreover, examples and simulations are given to illustrate the practical nature of the novel results.

WA2.2 P0632 1100 - 1120
Comparison of Different Subset Selection Algorithms for Learning Local Model Networks with Higher Degree Polynomials
Oliver BAENFER, Benjamin HARTMANN, Oliver NELLES
University of Siegen

A comparison of three different subset selection methods in combination with a new learning algorithm for nonlinear system identification with local models of higher polynomial degree is presented in this paper. Usually the local models are linearly parameterized and those parameters are typically estimated by some least squares approach. For the utilization of higher degree polynomials this procedure is no longer feasible since the amount of parameters grows rapidly with the number of physical inputs and the polynomial degree. Thus a new learning strategy with the aid of subset selection methods is developed to estimate only the most significant parameters. A forward selection method with orthogonal least squares, a stepwise regression and a least angle regression method are used for training different neural networks. A comparison of the trained networks shows the benefits of each subset selection method.

WA2.3 P0141 1120 - 1140
Linear Discrete-time Systems with Fuzzy Parametric Uncertainty
Petr HUSEK
Czech Technical University in Prague

The paper deals with the problem of determination of stability margin of uncertain linear discrete-time systems with parameter uncertainty described by fuzzy numbers. Arbitrary membership functions describing the uncertainty of coefficients of characteristic polynomial are considered. The presented solution is based on transformation of the original problem to Hurwitz stability test and generalization of Tsypkin-Polyak plot.

WA2.4 P0597 1140 - 1200
A Cooperative Interaction Control Methodology of a Pair Independent Control System
Xiaolin ZHANG
Tokyo Institute of Technology

Human eyes cannot easily focus on two separate targets at the same time. The two eyes have their own cooperative movements that can be separated into conjugate and ver-gence movements (relative movements) which have different dynamic characteristics. Here, in order to achieve realistic eye movements, first a binocular motor control sys-tem model was proposed based on the neural pathways of the binocular motor system. The model has cross pathways between the two symmetrical eyes fs own control loops which have never been found in any conventional robot control system. Consequently, the modification on this ex-taordinary feature model resulted that a pair of interacting control systems through the cross pathways can be sepa-rately analyzed into two independent control systems based on its behaviors, i.e. the conjugate movement control sys-tem and the relative movement control system. The effec-tiveness of this principle, then, was verified in the experi-ment through the binocular robot eye based on this pro-posed control system model. The constructed robot can op-erate several cooperative movement characteristics accord-ing to human-eye movements. For example, it cannot focus on two different targets at the same time, even though the targets have the same shape.

WA2.5 P0979 1200 - 1220
An Intelligent Fault-Tolerant Satellite Attitude Control System with-out Hardware Redundancies
Sureshkumar CHANDRASEKAR, Sundaram SURESH, Sundararajan NARASIMHAN, Narayanaswamy NAGARAJAN
Nanyang Technological University

An intelligent fault-tolerant control design based
on nonlinear adaptive control theory is proposed for microsatellite attitude control system, without providing for redundant actuators. An intelligent neural adaptive fault-tolerant control law, based on feedback error learning scheme is developed to aid the baseline controller. Using this control law, the control torques are suitably adjusted to achieve the desired target acquisition mode under a partial actuator failure in the roll direction. Simulation studies have been carried-out to examine the capabilities of the proposed fault-tolerant control system under partial actuator failure in the roll-axis. Results clearly show that the proposed intelligent controller is robust and requires a minimal settling time during the desired target acquisition mode.

### Session WA3 - Invited Session

**Date:** Wednesday, 08 December 2010  
**Time:** 1040 - 1220  
**Venue:** Canary II

### Multidimensional Systems Modeling and Signal Processing

**Chairs:** Yun ZOU  
* Nanjing University of Science and Technology

#### WA3.1 P0689  1040 - 1100

**Sufficient LMI Conditions for \( H_\infty \) Static Output Feedback Control of 2-D Systems**  
Zhi-Yong FENG, Li XU, Yoshihisa ANAZAWA  
Akita Prefectural University

This paper investigates the problems of \( H_\infty \) static output feedback (SOF) control of two-dimensional (2-D) discrete systems described by the Roesser model and Fornasini-Marchesini second model, respectively. By applying the 2-D Bounded Real Lemma combined with a slack variable technique, some sufficient linear matrix inequality (LMI)-based conditions for the existence of SOF controllers are established. Numerical examples are given to illustrate the effectiveness of the proposed LMI-based design method.

#### WA3.2 P0706  1100 - 1120

**Hybrid Traffics Congestion Control based on 2-D Hurwitz-Schur Stability**  
Pengxuan MAO, Yang XIAO, *Guangzh QIU, **Seok WOO, **Kiseon KIM  
Beijing Jiaotong University  
*Oakland University  
**Gwangju Institute of Science and Technology

Classical network fluid model and RED algorithm are based on TCP flows in internet network, and they have not considered the UDP flows’ effects in network. However, in real work of the network, the network link capacity is shared by the hybrid traffics: TCP flows and UDP flows, and UDP flows can occupy the original link capacity of TCP flow. Since there is no feedback control for UDP flows, the classical network fluid model and RED algorithm cannot reflect and control the congestion of TCP/UDP networks. To solve the problem, we modify the classical AQM router into multiple queues AQM router with classifier. We express the proposed TCP/UDP AQM router by a linear time-delay system model. Then, by utilizing the 2-D Laplace-Z transform technique, we derive some explicit conditions that establish the relationship between the control parameter pmax and the network stability. This paper first proposes parameter pmax's stability bounds for TCP/UDP routers for congestion control based on 2-D Hurwitz-Schur stability conditions. The simulation results verify that the proposed stability condition can gain the effective congestion control.
Session WA4

Date: Wednesday, 08 December 2010
Time: 1040 - 1220
Venue: Kingfisher

Sensor Network Systems

Chairs: Lihua XIE
Nanyang Technological University
Boon-Hee SOONG
Nanyang Technological University

WA4.1 P0985 1040 - 1100
Palm Size Charging Platform with Uniform Wireless Power Transfer
Yun YOU, Boon-Hee SOONG, Selvakumaran RAMACHANDRAN, *Wei LIU
Nanyang Technological University
*Singapore Institute of Manufacturing Technology

In this paper, the design of wireless inductive charger for portable electronic devices is present. There are two main parts have been included. The first part is the exciting circuit in which to provide sufficient input power to the primary charging platform. The exciting circuit is comprised by oscillator circuit and power amplifier circuit. Both of the two circuits have been simulated in software and verified by measurements. The second part is a two layer near uniform field planar inductive platform (primary coil). The design of the charging platform consists of two layers of square spirals overlapping each other using the principle of superposition. The strong areas (peaks) of one layer are superposition onto the weak areas (troughs) of the other layer. In this manner, a near uniform magnetic field suitable for power and signal transfer is created.

WA3.3 P0727 1120 - 1140
Stability Analysis for 2-D Discrete Systems with Varying Delay
Shuxia YE, Weigun WANG, Juan YAO
Nanjing University of Science and Technology

This paper is concerned with stability analysis for two-dimensional (2-D) discrete systems described by the Roesser models (RM) with varying delay in the state. By utilizing the delay partitioning idea and the Lyapunov method, a new stability criteria is proposed in terms of linear matrix inequalities (LMIs). This result is delay-dependent and also dependent on the partitioning size. A numerical example is given to demonstrate the effectiveness and the benefits of the presented methods.

WA3.4 P1129 1140 - 1200
2-D IIR Filter Bank Design by an LMI Approach
Huling Xu, Zhiping LIN, Cishen ZHANG, Anamitra MAKUR
Nanyang Technological University

This paper is concerned with the problem of the two-channel 2-D IIR filter bank design. Using a systematic optimization approach, which is solved in terms of an LMI, the 2-D IIR synthesis filters are designed such that the systems are alias free and then optimized to achieve approximate perfect reconstruction.

WA3.5 P0425 1200 - 1220
Linear Models for Plasma Current Control in Tokamak Reactors
Aitor J. GARRIDO, Izaskun GARRIDO, Jose M Goretti SEVILLANO, Modesto AMUNDARAIN, Mikel ALBERDI, Oscar BARAMBONES, Manuel DE LA SEN
University of the Basque Country

The control of plasma in nuclear fusion has been revealed as a promising application of Control Engineering, with increasing interest in the control community during last years. In this paper it is developed a control-oriented linear model for the control of plasma current. For this purpose, it is provided a summary of the background necessary to deal with control problems in tokamak-based nuclear fusion reactors as it is the case of the future ITER tokamak. Besides, it is also given a review of the most used simulators and plasma models, with the aim of providing an adequate background for control engineers to derive their own control-oriented model or to choose the appropriate existing one. Finally, the proposed plasma model performance is proven in a current drive profile trajectory tracking problem using a modified anti-windup PID-based control scheme.
environments and cannot be practically used for localization, we show that RSSI is a reliable indicator for the scanning phase and BS selection. More specifically, we develop a Distributed RSSI-Sharing technique to efficiently select BSs and create a simulation to test this technique. We implement and test technique on actual hardware with good results and finally propose RSSI-smoothing and a BS-Reduction method to improve the performance.

**WA4.3 P1135 1120 - 1140**

A Lower Bound on Expected Localization Error in Wireless Sensor Network

DI MA, Meng Joo ER, Hock Beng LIM, Bang WANG

Nanyang Technological University

Localization is an important research problem in WSNs (wireless sensor networks) and many WSN localization algorithms have been proposed in the literature. For a single sensor node whose anchors’ positions are known, the location estimation error lower bound can be computed by using the CRLB (Cramer-Rao Lower Bound). However, it is still unclear to the research community what the localization error lower bound is from a network point of view. In this paper, we derive a lower bound of the expected localization error for a network whose sensor nodes and anchors are randomly distributed according to a Poisson point process. We show that the lower bound of the expected localization error for a network is a function of the anchor density and the variance of anchor-to-sensor distance measurements.

**WA4.4 P1144 1140 - 1200**

Sensor Deployment Strategy for Random Field Estimation: One-Dimensional Case

Yang WENG, *Lihua XIE, **Wendong XIAO, ***Sen ZHANG

Sichuan University

*Nanyang Technological University

**Institute for Infocomm Research

***Singapore Polytechnic

Deploying the sensor nodes at the best locations for random field reconstruction via sensor network is a fundamental task. One-dimensional random field is a stochastic process. In this paper, we first propose an optimal sensor deployment strategy for Wiener process estimation. The optimal locations for the deployed sensors are uniformly distributed in the field. In addition, we propose a suboptimal sensor deployment to estimate the Gaussian random field which is described as an Ornstein-Uhlenbeck process. We show that the suboptimal deployment strategy for Gaussian random field is also uniformly distributed. Several simulations show the performance of our proposed deployment strategies.

**WA4.5 P0513 1200 - 1220**

Real Time Implementation of Modified Repetitive Control Strategy in a DC Motor

Vijayakarthick MUTHUKUMARAN, Sathishbabu SANTHANAM, P K BHABA

Annamalai University

In this paper the Modified Repetitive Control Strategy (MRCS) is designed and implemented in a DC motor. The MRCS incorporates the idea of repetitive control strategy (RCS) which accomplishes perfect asymptotic set point tracking in this process, provided that the period length used in the control formulation matches the actual period of the reference/disturbance signal exactly. The DC motor system is approximated into a First Order Plus Time Delay (FOPDT) model by step testing method. RCS is incorporated in the DC motor control loop of proportional (P) mode. The proportional controller parameter is obtained using Ziegler-Nichols Tuning Rule (ZNTR). The proposed MRCS is also integrated to a DC motor system. A periodic input signal of sine wave is generated and real time runs of the DC motor system are carried out for the periodic reference tracking with MRCS based P mode control loop. A similar run is also carried out with both RCS based P mode and conventional P-mode control structure in the loop. The experimental results show that the MRCS demonstrated good tracking performance. A robustness of the MRCS is also validated.
## Session WA5

Date: Wednesday, 08 December 2010

Time: 1040 - 1220

Venue: Nightingale

### Man-machine Interactions

**Chairs:**
- Juergen ROSSMANN  
  RWTH Aachen University
- Wenjie CHEN  
  Singapore Institute of Manufacturing Technology

### WA5.1 P0656 1040 - 1100

**Intuitive Robot Tool Path Teaching using Laser and Camera in Augmented Reality Environment**

Chuen Leong NG, Teck Chew NG, Thi Anh Ngoc NGUYEN, Guilin YANG, Wenjie CHEN  
Singapore Institute of Manufacturing Technology

This paper presents a new intuitive method for robot tool path teaching in Augmented Reality (AR) environment. Conventional industrial robot teaching method is long known to be either tedious or require a highly accurate virtual representation of robot work cell. Our method targets to provide the user with a fast and easy way of programming an industrial robot for useful tasks in a safe environment. In our system, a human robot interaction (HRI) system has been designed by fusing information from a camera and a laser range finder. The video images provide visual information to the user to operate the system, whereas the laser range finder captures the Cartesian information of the user intended robot working paths and trajectories. Furthermore, an AR environment has been designed where the virtual tool is superimposed onto the live video. The user simply needs to point and click on the image of the workpiece to generate the tool path. User can also adjust virtual tool orientation and simulate the tool trajectory in the AR environment, thus simplifying the robot teaching task. The proposed system has been tested for robot laser welding application. It is intuitive as no prior knowledge of robotic control is required in order to use our system. Most importantly, the system is safe and the user does not need to be physically close to the robot during path teaching.

### WA5.2 P0744 1100 - 1120

**An FSM based GUI Test Automation Model**

Yuan MIAO, Xuebing YANG  
Victoria University

Graphical User Interfaces (GUIs) constitute a large proportion of today’s software and are becoming more and more complex. Testing the correctness of GUIs and their underlying software is paramount for providing quality software products. Manual testing is extremely slow and unacceptably expensive. We present a new technique which enables the process of generating test cases and testing automation, based on an innovative model. Given a GUI based application, the set of GUI states and their running logic is modeled as a finite state machine (FSM). The efficiency of the model is formally analyzed and compared with event flow graph (EFG) model. The results show that our model is more efficient in storage.

### WA5.3 P0826 1120 - 1140

**A Motion-based Visual Interface for 3D Visualization and Robotic Control Applications**

Safiullah HUSSAINI, Wooi-Boon GOH  
Nanyang Technological University

The exploratory visualization of 3D data sets or multiple axis motion control of a monitoring camera mounted on a six-axis robot often require the user to control the viewing orientation and position of a camera view within a 3D space. This paper describes the design of an inertial motion sensing system, which uses only accelerometers to provide interactive 3D control of both orientation and position in such systems. We describe the interaction design strategies for exploratory visualization of 3D data using the proposed input device, which is mounted beneath a portable display. Experiments on the use of the proposed device suggest that with some training, the users are able to improve the speed with which they can navigate the orientation and position of a virtual camera to a desired target view in the 3D visual space.

### WA5.4 P0909 1140 - 1200

**Advanced Virtual Testbeds: Robotics Know How for Virtual Worlds**

Juergen ROSSMANN  
RWTH Aachen University

In recent years, virtual reality has emerged as a key technology for improving and streamlining design, programming, manufacturing and training processes. Based on experiences in the fields of space robotics, industrial manufacturing, multi-physics and virtual prototyping, "virtual testbeds" are currently being designed and implemented. Building on experiences gained in space robotics applications, the idea of "virtual testbeds" currently conquers new fields of applications in the manufacturing industry, on construction sites and even "in the woods". Interestingly, all fields can be supported with a rather generic and common basis so that the different applications can be realized very cost-efficiently. This paper is an attempt to give an overview over different current applications and setups. Furthermore, it will focus on the phases of a product's lifecycle that can already today be efficiently supported by virtual and augmented reality technologies. From a system theoretic standpoint, virtual testbeds are currently bridging the gap between virtual reality and robotics because on the one hand, robotics know how related to kinematics and physics based modeling is being used in virtual worlds to make them "behave realistically", on the other hand, those virtual worlds make very efficient
representations of "real worlds" in which planning systems for robotics can try out action alternatives quickly and without danger to the robotic hardware.

WA5.5  P0800  1200 - 1220
Service Discovery using Software Agents in Semantic Web
Nandini S SIDNAL, *Ravi S MALASHETTY, **Sunilkumar S MANVI
K.L.E.S.C.E.T, Belgaum
*VTU, Belgaum
**Reva Institute of Technology and Management

The Web, once solely a repository for text and images but now is evolving into an information provider as well as a tool to compute information. With this the internet computing will have a major role to play in the service oriented market places. Web Services are one of the fastest growing areas of information technology in recent years, also being a main motivating factor for internet computations in which, one of the services being service discovery. Automation of web service discovery is a must as the WWW has become a huge warehouse for storing information. This is possible by using software agents and becomes efficient by enriching web contents semantically. The Semantic Web (SW) is a medium where the data can be shared and processed both by automated tools and humans. The key point is in the automation and integration of the processes through machine readable languages. In order to use and connect all the information available on the Web, the software agents should be able to understand the information. The aim of the semantic Web service is to describe and implement Web services so as to make them more accessible to automated agents. This paper presents an overview of semantic web, software agents and integration of both to achieve better QoS.

Session WA6
Date: Wednesday, 08 December 2010
Time: 1040 - 1220
Venue: Pelican

Modeling and Identification

Chairs: Masoud SHAFIEE
Amirkabir University of Technology,
Tehran
Lakmal D SENEVIRATNE
King’s College London

WA6.1  P0704  1040 - 1100
Identification of the Parameters of Robot Manipulators Dynamics about an Operating Point using Perturbed Dynamics
Azeddien KINSHEEL, *Zahari TAHA
University of Malaya
*University Malaysia Pahang

In this paper, a new approach to identify the parameters of robot manipulator dynamics is presented. The approach is based on exciting the robot manipulator with multiple identification trajectories that pass through the operating point with specific speeds and accelerations. The position, velocity and acceleration of the robot joints along with the corresponding torque at the operating point are recorded. The relative change of the joint motion and the corresponding torque compared to a reference operating point trajectory is used to identify the robot dynamics parameters. By using perturbed rather than the absolute motion values, several modeled and un-modeled effects can be eliminated from the identification equations. This is very useful when an accurate model of the robot dynamics at specific operating point(s) of the workspace is required.

WA6.2  P1012  1100 - 1120
Descriptor Modeling and Response Analysis of Two Rigid-Flexible Cooperative Arms
Ehsan SAMIEI, Masoud SHAFIEE
Amirkabir University of Technology, Tehran

In this paper, a descriptor dynamic model for a two-cooperative rigid-flexible link manipulators system which holds a rigid object in a horizontal workspace is derived. When a system of multi manipulators grasps an object, they form a closed chain that its equations consist of some algebraic constraints as well as dynamic equations. These algebraic constraints can cause impulsive behaviors in the system response and must be considered in modeling and control. Moreover, some of these algebraic constraints are dependent to each other and must be neglected in order to reach to the minimal form of the model. In this paper, a dynamic model for a rigid-flexible link manipulator which is derived in many literatures based on Lagrange equation and assumed mode method is considered. Then, the Minimal constraints equations of the
system are derived. The closed chain motion of manipulators and constraints are linearized around the rigid-body motion, and a linearized dynamic descriptor model of the system which is the absolute description of the whole system is obtained. Finally, by using descriptor system theory, the behavior of the system is investigated. To evaluate the proposed method, a simulation was performed on a two-cooperative flexible-link manipulator system.

**WA6.3 P1018 1120 - 1140**

**Topology Presentation and Analysis of Carton Manipulation**

Guowu WEI, Rui Rui ZHANG, Jian S DAI  
King's College London

This paper presents models for description and identification of various cartons in their discrete states, and proposes a new approach to describe the transformation of configuration states during carton manipulation in a packaging process. The method makes use of matrix operations which can be used to identify and model the steps and changes in carton manipulation at different stages of a packaging process. This gives an analytical way of presenting and identifying information of a carton and of modeling carton packaging manipulation and presents a new way for carton packaging automation.

**WA6.4 P1060 1140 - 1200**

**Finite Element Modelling of Rolling Indentation for Tissue Adominality Identification**

Kiattisak SANGPRADIT, Kaspar ALTHOEFER, Lakmal D SENEVIRATNE  
King's College London

We describe a novel approach for demonstrate of a wheel-rolling tissue deformation as well as the abnormalities tissue depth evaluation using a rolling finite element model (RFEM). Since a wheeled probe which is capable of performing rolling tissue indentation has been proven to be a promising device to rapid conduct soft tissue property identification for localization and documentation of the abnormalities within the tissue, with the aim of compensating the loss of haptic and tactile feedback experienced during robotic-assisted minimally invasive surgery (MIS) [3, 4, 5]. To implement such a device requires a good understanding of the dynamics of the wheel-tissue rolling interaction and relationship between the tissue internal structure and the corresponding tissue reaction force. In this paper we propose the RFEM of the dynamic interaction between a wheeled probe and a soft tissue sample using ABAQUS finite element analysis software package. The aim of this work is to more precisely locate abnormalities depth within soft tissues using RFEM and aid surgeons better in the decision of resection during MIS through the understanding of dynamics of wheel-tissue rolling interaction. The soft tissue was modelled as a nonlinear hypereelastic material with geometrical nonlinearity and the modelling parameters were calibrated using experimental data from standard tests. The purposed RFEM consists of simulations of wheel-tissue rolling indentations on a silicone phantom with varied tissue internal structure and also running on a biological tissue such as a porcine kidney. The results show that the proposed method can predicted the wheel-tissue interaction force of the rolling indentation with a good agreement results and the documentary from empirical equation of RFEM can identify the simulated tumors depth accurately.

**WA6.5 P0356 1200 - 1220**

**The Narcissistic Robot: Robot Calibration using a Mirror**

Matthias RÜTHER, Martin LENZ, Horst BISCHOF  
Graz University of Technology

We present a novel method for calibration of a robotic manipulator. The robot kinematic chain and its tool are observed by a hand mounted camera through a mirror. We show the possibility of enabling hand-eye, hand-tool, and kinematic robot calibration without incorporating accurate external references, except the mirror. Using this particularly simple setup, hand-eye calibration becomes independent of the kinematic chain and parameter observability constraints in kinematic calibration become more relaxed, which makes pose planning for robot calibration more convenient.
Session WA7
Date : Wednesday, 08 December 2010
Time : 1040 - 1220
Venue : Oriole
Robot Control I

Chairs : Chien Chern CHEAH
Nanyang Technological University
Adel AKBARIMAJD
University of Mohaghegh Ardabili

WA7.1 P0509 1040 - 1100
A Learning Approach to Optimize Walking Cycle of a Passivity-based Biped Robot
Nima FATEHLI, *Masoud ASADPOUR, **Adel AKBARIMAJD, ***Laila MAJDI
Qazvin Islamic Azad University
*University of Tehran
**University of Mohaghegh Ardabili
***Islamic Azad University, South Tehran

A learning mechanism based on Powell’s optimization algorithm is proposed to optimize walking behavior of a passivity based biped robot. To this end, a passivity-based biped robot has been simulated in MSC ADAMS and a control policy inspired from humanoid walking is adopted for a stable walking of the robot. Linear controllers try to control the joints of robot in each walking phase to implement the gait proposed by the control policy. Learning is employed using Powell’s optimization algorithm to adjust the control parameters so that the robot enters to an optimum limit cycle in a finite time. The fitness function is defined to evaluate the robot’s optimum behavior. The results are verified by simulations in SIMULINK+ADAMS.

WA7.2 P0584 1100 - 1120
Bipedal Robot Walking Strategy on Inclined Surfaces using Position and Orientation based Inverse Kinematics Algorithm
Fariz ALI, Aliza CHE AMRAN, Atsuo KAWAMURA
Yokohama National University

This paper proposes a strategy for bipedal robot walking on inclined surfaces using position and orientation based inverse kinematics algorithm. Some researchers implemented control approaches to solve bipedal walking on inclined surfaces. Generally, most of them apply control feedback at ankle joints and also introduced many more control methodologies. In this paper, inverse kinematics methodology is introduced systematically for bipedal walking on inclined floor. Positions and orientations are embedded into the kinematics calculation. In this strategy, a working bipedal robot walking pattern for flat floor must be developed first. Then, the same walking pattern can be used for the inclined floor with orientation included so that the bipedal robot is able to walk on the inclined floor successfully. This methodology will distribute the angles caused by the inclined surfaces to the appropriate robot joints. By doing this, control at ankle joints only is avoided. A 3-D dynamics simulator which is known as Robot Control Simulator and developed in our laboratory is used for simulation in order to validate our proposed method.

WA7.3 P0267 1120 - 1140
Experimental Investigation of Fundamental Properties of Snake Robot Locomotion
SINTEF ICT
*Norwegian University of Science and Technology

This paper derives and experimentally investigates fundamental properties of the velocity of a snake robot conducting lateral undulation. In particular, the derived properties state that the average forward velocity of the snake robot 1) is proportional to the squared amplitude of the sinusoidal motion of each joint of the robot, 2) is proportional to the angular frequency of the sinusoidal motion of each joint, 3) is proportional to a particular function of the constant phase shift between the joints, and 4) is maximized by the phase shift between the joints that also maximizes the particular phase shift function. The paper presents an experimental investigation of the validity of these derived properties by measuring the forward velocity of a physical snake robot during lateral undulation. The experimental results support the theoretical findings.

WA7.4 P0717 1140 - 1200
NARMA-L2 Controller for 2-DoF Underactuated Planar Manipulator
Adel AKBARIMAJD, Solmaz KIA
University of Mohaghegh Ardabili

NARMA-L2 controller is designed for a 2R planar underactuated robot. To this end, in system identification stage, after appropriate selection of system output, the network is trained in order to approximate dynamics of the manipulator. Then control law is determined to make the system output follow the reference input. Tracking test and disturbance tests are performed by doing Simulations in SimMechanics. The results show that the controller stabilizes the system.

WA7.5 P0445 1200 - 1220
Cell Sorting with Combined Optical Tweezers and Microfluidic Chip Technologies
Xiaolin WANG, Zuankai WANG, Dong SUN
City University of Hong Kong

Sorting of specific target cells is an important process in biotechnological research and clinical medicine. This paper proposes a methodology that integrates optical tweezers and microfluidic chip technologies to realize the automatic cell sorting in a continuous flow environment. In the proposed system, cells are driven through the region of interest, and the digital image processing technique
is utilized to recognize the target cells. The optical tweezers are used to move the cells selected by image processing to the desired area. In order to move the target cells to the collection reservoir more quickly and reduce the cell-cell interactions (e.g., clustering or jamming), the motion of optical tweezers is further investigated. The relationship between the laser power and the cell maximal escape velocity has been studied to achieve the robust cell sorting with lower power. The idea of multi-trap parallel processing is proposed to achieve high throughput without losing the purity. Utilizing the proposed cell sorter, we can collect rare cells from a sample of primary tissue without expansion, with less damage and higher accuracy.

Session WA8
Date: Wednesday, 08 December 2010
Time: 1040 - 1220
Venue: Bluebird

Vision Applications
Chairs: Eric SUNG
Nanyang Technological University
Ying SUN
National University of Singapore

WA8.1 P0224 1040 - 1100
On Line Quality Inspection in Tailor Welded Blank based on Laws Texture Energy and Structured Light
Chengning ZHANG, Min XU, Mingyang ZHAO, Haibo LUO
Chinese Academy of Sciences

Tailored blank laser welding has become a critical joining process in a number of manufacturing industries, including automotive, medical, and aerospace. Even if the welding process involves very high-tech equipment, the final product is not necessarily free of defects such as lack of fusion or penetration and porosities. This is the reason why it is important to inspect the welds quality. The conventional method for the quality inspection of weld seams is based on the structured light deformation, however, if a weld seam hasn’t a groove profile, and this method is limited. A new method based on combination of Laws texture energy and structured light is proposed in this paper. A weld seam region and a structured light region are extracted respectively, and then the intersection operation with respect to the two regions can be carried out. The given method can also inspect weld seams without structured light deformation. Experiments are conducted with this method, then the considered width measurement is well measured and weld defects can also be detected.

WA8.2 P0918 1100 - 1120
Computed Tomography Guided Laparoscopy: Proof of Concept
Adrian PARK, Erica SUTTON, Raj SHEKHAR
University of Maryland School of Medicine

Current generation minimally invasive surgeries present many visualization challenges, including two-dimensional representation of three-dimensional anatomy and a lack of visualization of deeply recessed structures. Coupled with the loss of tactile feedback which places greater emphasis on available visual cues, improved surgical visualization remains a long-standing need. Our response to address this need is Live Augmented Reality (Live AR), in which processed images from live radiologic scans of the surgical field are merged with optical images, accounting for spatial and temporal registration. We have demonstrated the feasibility of Live AR, but its clinical implementation is hampered by many current
technical limitations. In this report, we have presented guidance of a simple laparoscopic maneuver completely based on computed tomography (CT) scanning and rapid 3D rendering of the acquired images in the CT room. The capability developed here and the reported results constitute a step toward the eventual goal of routine clinical implementation of Live AR.

WA8.3 P0944 1120 - 1140
Exposure Balancing and Difference Blurring to Eliminate Seam-lines in a Real-time Bird’s Eye View Monitor
Sangseok HONG, JinSoo LEE, *Sang-Bok CHOI 
Pohang University of Science and Technology
*HANSERO FA Co., Ltd.

A Bird’s Eye View Monitor usually shows visible seam-lines. Previous seam-line elimination methods limit the dynamic range of mosaicked image and require that the reference images are equal geometrically the regions that overlap. In this paper, we propose a camera model based alternative exposure compensation algorithm which controls brightness of reference images using calculated offset, and a seam-line difference blurring algorithm which gradually spreads the pixel by pixel difference of a seam-line over across the seam-line with no geometrical assumption. Moreover, we generalize the compensation algorithm for a circularly positioned and consecutively positioned N reference image mosaicking system. Our approach aims at extending the dynamic range, eliminating ghost images, and increasing system efficiency. Proposed algorithms run on real-time systems. Results are demonstrated using several images.

WA8.4 P0881 1140 - 1200
Correction of Paradoxical Vision by Simulated Depth Cue and Inverted Mirror Image for Laparoscopic Surgery
Takuro ISHII, Chang-Ping KU, Tatsuo IGARASHI, *Harufumi MAKINO, **Yukio NAYA
Chiba University
*Naruto Hospital
**Teikyo University Chiba Medical Center

In laparoscopic surgery, surgeons often encounter paradoxical vision according to their position against the camera position. Such a paradoxical vision evokes confusion and surely deteriorates surgical performance. Previous researches indicated inverted mirror image is useful to compensate this problem though upside-down inversion makes depth sensation perplex. To solve the dilemma, we proposed modified method that displays inverted mirror image plus perspective projection that adds simulated depth cue. After preparing the image adjustment software, trainer box, touch panel device to measure the motion of the forceps, we tested its validity in 36 participants including 10 experienced surgeons. Each participants were requested to push buttons following computer fs assignment for ten times of task at three conditions: 1. stands parallel to the camera, 2. stands at the opposite side of the camera, 3. stands at the opposite side of the camera watching inverted mirror image with perspective projection. Mean duration of time for completion of the task was 23.1+/−5.0 seconds for the subjects stand parallel to the camera. It was 98.0+/−96.5 seconds and 43.3+/−24.3 seconds for the subject stands at the opposite side of the camera without and with transformed image, respectively. Paradoxical vision significantly deteriorated performance (p<0.001), however, it was compensated by the inverted mirror vision with perspective projection significantly (p<0.0015). In grope passing h and gbead drop h trial, tested by 10 experienced surgeons, inverted and perspective vision significantly compensated deteriorated performance under paradoxical vision. Inverted mirror image with perspective projection would be useful tool for correction of paradoxical vision in laparoscopic surgery, and further research would be warranted to make such system practical.

WA8.5 P0349 1200 - 1220
Retinal Blood Vessel Segmentation via Graph Cut
Ana G SALAZAR-GONZALEZ, Yongmin LI, Xiaohui LIU 
Brunel University

Image analysis is becoming increasingly prominent as a non intrusive diagnosis in modern ophthalmology. Blood vessel morphology is an important indicator for diseases like diabetes, hypertension and retinopathy. This paper presents an automated and unsupervised method for retinal blood vessels segmentation using the graph cut technique. The graph is constructed using a rough segmentation from a pre-processed image together with spatial pixel connection. The proposed method was tested on two public datasets and compared with other methods. Experimental results show that this method outperforms other unsupervised methods and demonstrate the competitiveness with supervised methods.
### Session WM1

**Date:** Wednesday, 08 December 2010  
**Time:** 1330 - 1530  
**Venue:** Ball Room

**Panel Session on “Imaging and Vision: Challenges and Opportunities”**

**Chairs:** Professor Kar-Ann TOH  
Yonsei University, Korea

**Panelists:**  
Professor Zhi-Qiang LIU  
City University of Hong Kong, SAR, China  
Professor Brian C. LOVELL  
University of Queensland, Australia  
Professor Massimo TISTARELLI  
University of Sassari, Italy  
Professor Zhengyou ZHANG  
Microsoft Research (MSR), USA

### Session WM2

**Date:** Wednesday, 08 December 2010  
**Time:** 1330 - 1530  
**Venue:** Canary I

**Process Control**

**Chairs:** Vaidehi VIJAY  
Anna University, Chennai  
Peng YANG  
Hebei University of Technology

**WM2.1 P0197 1330 - 1350**  
**Relative Gain Array for MIMO Processes Containing Integrators and/or Differentiators**

Wuhua HU, Wen-Jian CAI, Gaoxi XIAO  
Nanyang Technological University

Limitations are revealed for the existing methods to derive relative gain array (RGA) for a MIMO process containing integrators and/or differentiators. This paper proposes a new method to overcome these limitations. The method can handle processes described by either transfer functions or state-space models. The effectiveness and simplicity of the proposed method are illustrated with examples where the existing methods fail to give valid RGAs.

**WM2.2 P0223 1350 - 1410**  
**Overriding Control for Stability with Manifest Variables**

Tri TRAN  
University of Technology, Sydney

This paper presents a new method of stabilizing closed-loop systems, whereby instability warnings and overriding controls are performed. The system stability is maintained by having a separated agent, here called stabilizing agent, to produce corrective actions to the manipulated variables. This agent computes the stabilizing thresholds on-the-fly based on dissipative projections and real-time stability conditions. It overrides the controller outputs with stabilizing values once the threshold is violated. The plant models are not employed in this approach. Instead of that, online information of manifest variables is utilized to evaluate necessary bounds on manipulated variables for the stability purpose. Theoretical results are illustrated in simulation of a model predictive controller for an unit operation of the paper mill.

**WM2.3 P0552 1410 - 1430**  
**Output Feedback Control for Nonlinear System based on Local Linear Model Trees (LOLIMOT)**

Yan ZHANG, Linan ZU, Peng YANG, Guolin XING  
Hebei University of Technology

A nonlinear adaptive output feedback control approach based on LOLIMOT is proposed for a class of nonaffine system in the non-strict feedback form with unknown nonlinearities in this paper. In order to
overcome the disadvantages of output feedback control, LOLIMOT which can identify the nonlinear system accurately is applied. During the control process, backstepping approach is utilized to design the adaptive output feedback controller and the internal pseudo-controller is used as one-step predictor. The effectiveness of proposed scheme is shown by simulation on a proper nonlinear system.

**WM2.4 P0850 1430 - 1450**

Applications of Convex Optimization in Plant-wide Control of Membrane Distillation Bio-Reactor (MDBR) Water Recycling Plant

Avinash VIJAY, Keck Voon LING, Anthony GORDON FANE
Nanyang Technological University

The objective is to develop a control system that will enable the Membrane Distillation Bio-Reactor (MDBR) water recycling plant to become self sufficient and fully automatic. In order to ensure continuous operation, the control system must maintain conditions required for the micro-organisms to survive. These requirements need to be met even when solar radiation and weather conditions are not conducive for water production. Hence, maintenance of a back up reserve is necessary. A balance has to be struck between minimization of power consumed and maximization of output produced to facilitate smooth operation. Control is implemented through a hierarchical framework that keeps track of the different plant objectives. Operational set points are determined through convex steady state optimization. Current set points are based on predictions regarding variation in solar radiation within the planning horizon.

**WM2.6 P1105 1510 - 1530**

Investigation of Thermal Effect in Permanent Magnet Linear Motor Stage

Singapore Institute of Manufacturing Technology
*Nanyang Technological University

Thermally induced deformation has become more of a concern for precision machines as accuracy is getting more stringent. Unlike other indirect drives which are possible to isolate or place rotating motors, which are heat sources, away from the working area. A linear motor is a direct drive system which is heat source and placed near to the working area. Therefore, this thermal effect characteristic study is conducted here to find out the effect of heat that is transferred and dissipated around the working area, causing unwanted deformation. The surface area joining the linear motor coil to the application carriage is large. It will be inaccurate to assume a constant temperature or heat flux through the entire surface. The temperature of the surface is different for different location and time. Experiments are conducted to investigate the surface temperature and heat flux profile in different application processes. Finally, the result of this investigation can define the heat source accurately so that a further study could develop a prediction scheme for the deformation of the carriage. This finding can be applied to error budgeting for machine design stages.

**WM2.5 P0926 1450 - 1510**

First and Second Moment Control of Linear Stochastic Discrete Time Systems

Fateme ROHANI, *Hamid KHALOOZADEH, **Roya AMJADIFARD
Islamic Azad University, Tehran
*K. N. Toosi University of Technology
**Tarbiat Moallem University, Tehran

This paper deals with control of first and second moment of the states of linear stochastic discrete-time systems. In this paper, the expectation and covariance of the states are combined together to construct a new higher order system. Our approach tends to use the covariance and the expectation of the states as feedback signals to obtain the appropriate control signal which leads the states of the open loop system to a prescribed value for expectation vector and covariance matrix. The resulted system is deterministic, so we would be able to choose any well-defined control design method. In this paper, the method is based on integral control approach. The expectation and covariance of any state of the system are guaranteed to track the desired corresponding values.
Session WM3
Date: Wednesday, 08 December 2010
Time: 1330 - 1530
Venue: Canary II

Co-operative Control
Chairs: Kamesh SUBBARAO
*The University of Texas at Arlington
Joseph J YAME
University Henri Poincare

<table>
<thead>
<tr>
<th>WM3.1 P0210</th>
<th>1330 - 1350</th>
<th>Asymptotic Synchronization and Collision Avoidance for Multi-agent Flocking</th>
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</thead>
<tbody>
<tr>
<td>Zhiyong CHEN, Hai-tao ZHANG, Chao ZHAI</td>
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<td>University of Newcastle</td>
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<td>*Huazhong University of Science and Technology</td>
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A novel individual-based alignment/repulsion algorithm is proposed in this paper for a flock of multiple agents. With this algorithm, each individual repels its sufficiently close neighbors and aligns to the average velocity of its neighbors with moderate distances. In both mathematical analysis and numerical simulation, we prove that the algorithm guarantees an uncrowded flocking behavior with asymptotical velocity synchronization when sufficiently intensive communication exists within the agents. Moreover, we provide the conditions for collision avoidance along the whole transient procedure. The proposed flocking model has its references in natural collective behaviors like escaping panic and traffic jam motions.

<table>
<thead>
<tr>
<th>WM3.2 P0249</th>
<th>1350 - 1410</th>
<th>Weight Balance for Directed Networks: Conditions and Algorithms</th>
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<tbody>
<tr>
<td>Yuan FAN, Gang FENG, Yong WANG</td>
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<tr>
<td>University of Science and Technology of China</td>
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<td>*City University of Hong Kong</td>
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Consensus strategies find extensive applications in coordination of robot groups and decision making of agents. Since balanced graph plays an important role in the average consensus problem for directed communication networks, this work explores the conditions and algorithms for the digraph balancing problem. It has been proved that a directed graph can be balanced if and only if the null space of its incidence matrix contains positive vectors. Then two weight balance algorithms have been proposed, and the conditions for obtaining a unique balanced solution have been investigated. This work has also pointed out the relationship between the weight balance problem and the features of the corresponding underlying Markov chain. Finally, two numerical examples are presented to verify the proposed algorithms.

<table>
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<tr>
<th>WM3.3 P0282</th>
<th>1410 - 1430</th>
<th>Robust Cooperative Leader-Follower Formation</th>
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Flight Control
Weihsua ZHAO, Tiauw Hiong GO
Nanyang Technological University

This paper addresses the application of Model Predictive Control (MPC) approach for the Leader-followers formation flight problem. Under the robust decentralized unified MPC framework, the current collision avoidance scheme has been extended to take care of any shape and small pop-up obstacles. And in the heterogeneous Leader-follower situation, if the formation error term is added to the Leader’s cost function, then the formation will be maintained. The simulation results show that the modified decentralized MPC framework can successfully achieve and keep collision-free formation flights.

<table>
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<tr>
<th>WM3.4 P0500</th>
<th>1430 - 1450</th>
<th>Stability Analysis of Local Swarms</th>
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<tr>
<td>Liangshun WANG, Huajing FANG</td>
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<td>Huazhong University of Science and Technology</td>
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This paper considers finite sense ability and finite motion ability into swarm system. We first construct a model of local swarms with a class of attraction and repulsion. Then we analyze their aggregation motion on the basis of the model. It is shown that the individuals of the two swarms will aggregate and eventually enter into a bounded hypeball around the swarm center in finite time. We finally analyze their motion in convergent region.

<table>
<thead>
<tr>
<th>WM3.5 P0529</th>
<th>1450 - 1510</th>
<th>Asynchronously Dynamic Averaging Estimation with Communication Constraints</th>
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<tr>
<td>Dequan LI, Xiaofan WANG</td>
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<td>Shanghai Jiaotong University</td>
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The paper concerns with the problem of asynchronous gossip-based dynamic averaging estimation with communication constraints, where each agent estimates the local time-varying parameters individually, then random pairs of connected agents iteratively and locally perform a pairwise average of their estimations through quantized information communication. How quantization affects the evolution of the gossip-based dynamic averaging estimation algorithm is investigated. We prove that the agents’ states converge to a random variable that deviates from the average of the estimated parameters. We derive a strong result about the upper bound for the asymptotic mean square error of the states, which just captures effect of the quantized precision and is independent of the network parameters.

<table>
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<tr>
<th>WM3.6 P1071</th>
<th>1510 - 1530</th>
<th>A Constrained Dynamical Systems Approach for Attitude Consensus of Multiple Rigid Bodies</th>
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<tr>
<td>Divya BHATIA, Kamesh SUBBARAO</td>
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<td>The University of Texas at Arlington</td>
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This paper presents a constrained dynamical systems based attitude synchronization and tracking
for multiple rigid bodies. The attitude dynamics of multiple vehicles are coupled via explicit constraint functions that mirror a priori communication topologies. Additional constraint functions are imposed to achieve specific consensus and formation objectives. The constraint stabilization is achieved via a modified Baumgarte stabilization method that includes an integral term. The performance of these constrained dynamics-based formations is evaluated for bounded control authority.

Session WM4
Date: Wednesday, 08 December 2010
Time: 1330 - 1530
Venue: Kingfisher

Adaptive Control
Chairs: Koshy GEORGE
PES Institute of Technology
Kai ZENERG
Aalto University

WM4.1 P0422 1330 - 1350
Well-Posedness of Two Classes of Singular Distributed Parameter Systems in Hilbert Space
Feng LIU, *Guodong SHI, **Delin CHU
Jiangsu Teachers University of Technology
*Changzhou University
**National University of Singapore

One of the most important problems for the study of singular distributed parameter systems is the well-posedness. Not only is it very important for the study of stability of singular distributed parameter systems, but also it is the theoretic basis for the study of the related problem of optimal control. In this paper, the concepts and the properties of generalized operator semigroup (GOS) and generalized integral semigroup (GIS) are given in Hilbert space, the solving problem of the non-homogeneous singular distributed parameter system is discussed by the concepts and the properties of GOS and GIS in Hilbert space, and some important results of the two classes of singular distributed parameter systems are given.

WM4.2 P0514 1350 - 1410
Feedforward Multiple Harmonic Control for Periodic Disturbance Rejection
Kai ZENERG, *Ali ALTOWATI, **Kari TAMMI, Eero VESAJOA
Aalto University
*University of Garyounis
**VTT Technical Research Centre of Finland

The paper discusses compensation of several sinusoidal disturbance signals entering the system simultaneously. The disturbances may have different frequencies, amplitudes and phases. A modification of the well-known LMS algorithm is proposed, which makes a direct feedforward compensation algorithm possible. It is demonstrated that the problems of the standard LMS algorithm, when several disturbance frequencies enter the system simultaneously, can now be avoided with a multidimensional LMS algorithm. The performance is demonstrated by extensive simulations.

WM4.3 P0816 1410 - 1430
Adaptive Control of a Class of Nonlinear Systems using Support Vector Regression
Koshy GEORGE, *Prashanth HARSHANGI  
PES Institute of Technology  
*PES Centre for Intelligent Systems

In this paper we demonstrate an improvement in the transient tracking performance when a Support Vector Regression (SVR) is used to identify a nonlinear ARMA plant. We use an on-line version of SVR, and at each instant, the identified model is used to determine the appropriate control law. A further improvement in the transient performance is shown with the methodology of multiple models, switching, and tuning.

WM4.4 P0904 1430 - 1450

A Sub-Region Boundary-Based Control Scheme with a Least-Squares Estimation Algorithm for an Underwater Robotic System
Zool H ISMAIL, Matthew W DUNNIGAN  
Heriot-Watt University

A new control concept is proposed for an underwater vehicle-manipulator system (UVMS) where the desired target is defined as a region boundary rather than a point or a region. For a mapping of the uncertain persistent effects i.e., the restoring forces, a least-squares estimation algorithm along with the inverse Jacobian matrix is utilized in the adaptive control law. The unit quaternion representation is used for the attitude representation. The stability analysis is carried out using a Lyapunov-like function. Simulation results are presented to assess the effectiveness of the proposed control scheme.

WM4.5 P0905 1450 - 1510

An Adaptive Region Boundary-Based Control Scheme for an Autonomous Underwater Vehicle
Zool H ISMAIL, Matthew W DUNNIGAN  
Heriot-Watt University

A new control concept is proposed for an underwater vehicle-manipulator system (UVMS) where the desired target is defined as a region boundary rather than a point or a region. For a mapping of the uncertain persistent effects i.e., the restoring forces, a least-squares estimation algorithm along with the inverse Jacobian matrix is utilized in the adaptive control law. The unit quaternion representation is used for the attitude representation. The stability analysis is carried out using a Lyapunov-like function. Simulation results are presented to assess the effectiveness of the proposed control scheme.

WM4.6 P0876 1510 - 1530

Decentralized Adaptive Practical Tracking of Nonlinear Interconnected Systems with Dynamic Input and Output Interactions
Lixia HAN, Huijin FAN  
Huazhong University of Science and Technology

In this paper, the adaptive practical output tracking problem on a class of nonlinear interconnected systems is considered, in which the dynamic interactions and unmodelled dynamics depend on both the subsystem inputs and outputs. Under the assumption that both the references and their first-order derivatives are bounded, decentralized adaptive backstepping controllers have been proposed to make sure that all the signals in the interconnected systems are globally uniformly bounded, with the tracking errors converging to a small set around the origin.
This paper is devoted to discuss the role of the minimum residence time in the stabilization of dynamic discrete switched systems. It is found that it can be obviated if the sampling period is sufficiently large even without imposing the known requirement in the continuous-time case that the various switched parameterizations (also often referred to as "configurations") possess a common Lyapunov function. However, it is claimed that the same role related to needing a sufficiently large minimum residence time at each stable parameterization in the continuous-time case is now played by the need of a sufficiently large minimum stabilizing sampling period. This requirement is removed if the various parameterizations possess a common Lyapunov function.

This paper presents the first part of study on the proposed automatic optimal reclaiming system. The proposed system focuses on how the reclaimer reclaims iron ore from stockpiles to fulfill quality grade target aiming for minimum reclaimer overall movement. For example, iron ore can be excavated from open-cut pits, stacked onto stockpiles and reclaimed later using bucket wheel reclaimer (BWR) for export to customers. Stockpiles here are represented by combination of voxels each possessing certain quality distribution. The supply of iron ore closest to the target grade with lower operation cost is the main concern for the ore producer. Currently, BWRs are operated manually to meet quality grade demand involving the checking of quality periodically during reclaiming operation. In result, there is excessive movement of the large machine leading to higher energy consumption. In this paper, the combination of voxels is identified from available stockpile voxels considering BWR minimum movement to fulfill quality and quantity demand of iron ore. Achieving the desired grade with maximum efficiency will result in increasing productive rates and less impact on global warming by significantly reducing energy consumption.

We present a modular evolutionary framework, coined CASE for "complex adaptive system evolver", to automate the modeling and analysis of agent-based simulations (ABSs). The field of agent-based modeling is rapidly growing due to its capabilities to expose the emerging complex phenomena occurring in a wide range of natural and artificial systems such as biological cells, societies, battlefields, stock markets, etc. Nevertheless, studying agent-based simulations is a complicated, interdisciplinary and time-consuming process. Indeed, a large number of simulation parameters has to be considered to identify and fully understand the conditions leading to the emerging phenomena of interest. To tackle this difficulty, the study of ABSs is thus typically conducted in an iterative manner, where each iteration includes the successive and manual modeling of ABSs and analysis of simulation outcomes. To automate this iterative and time-consuming process, we propose CASE, a platform-independent framework capable of evolving ABSs to exhibit the desired emerging behaviors. Through this evolutionary approach, the examination, i.e., the modeling, execution and analysis, of ABSs is automated. This process automation significantly facilitates the examination of complex systems using ABSs. In this paper, we present in detail this modular evolutionary framework which is illustrated with an example experiment. In this experiment, CASE is utilized for Automated Red Teaming, a simulation-based vulnerability assessment technique commonly employed by defense analysts. The aim of this paper is to introduce this flexible computational framework which may potentially benefit related fields involving agent-based simulations such as the gaming or financial industries.
variables. A fault severity evaluation method is then proposed based on the modified SDG model, where the nodes can take values (±1), (±3) and (±6). Then, an index named DoF is developed to measure fault severity. The application results can verify the effectiveness and feasibility of the proposed method.

WM5.5  P0484  1450 - 1510
A Multi-Purpose Remote Controller based on Bluetooth Mobile Phone
Chih-Hung WU, Li-Shan MA, Yu-Jyun CAI, Ting-Fu YEH
Chienkuo Technology University

In this study, a multi-purpose remote controller based on Bluetooth mobile phone (MRCBMP) is proposed to provide users for a convenient control interface. The IR, RF and Bluetooth modules are integrated into the microcontroller module cooperated with Bluetooth mobile phone by Bluetooth module. By MRCBMP, users can control IR, RF and Bluetooth controlled objects without the numerous conventional remote controllers.

WM5.6  P1026  1510 - 1530
Speed Optimization for Micropipette Motion during Zebrafish Embryo Microinjection
Shengfeng ZHOU, Peter C Y CHEN, *Zhe LU, Joo Hoo NAM, **Hong LUO, Ruowen GE, Chong Jin ONG, **Wei LIN
National University of Singapore
*University of Toronto
**Singapore Institute of Manufacturing Technology

This paper presents an approach to optimize the zebrafish-embryo microinjection process by selecting suitable speed trajectories for the motion of the micropipette, with the objective of minimizing the risk of damaging the embryo during the microinjection process. A viscoelastic model of a zebrafish embryo is developed based on experimental data. The speed optimization problem is formulated based on this viscoelastic model. Simulation results indicate that there exists an optimal speed trajectory for the micropipette under certain conditions. The key benefit of this speed optimization approach is that the turgor pressure inside the membrane is prevented from increasing significantly during the microinjection process, thus avoiding damaging the biological components in the embryo.

Session WM6
Date :  Wednesday, 08 December 2010
Time :  1330 - 1530
Venue :  Pelican

Mobile Robotics I
Chairs :  Maulin M JOSHI
         Sarvajanik College of Engineering and Technology, Surat

WM6.1  P0227  1330 - 1350
Experiences with Online Local Model Predictive Control for WMR Navigation
Lluis PACHECO, Ningsu LUO
University of Girona

Path-tracking by using MPC (model predictive control) is a suitable control science solution for mobile robot navigation applications. Online MPC is reported by using short-term horizons that allow dealing with flexible path-tracking and reactive behaviors. The majority of MPC experimental research developed is based on the fact that the reference trajectory is known beforehand. However, under dynamic environments the global solution becomes unfeasible for the majority of applications where the scenario should be considered as partially unknown due to the lack of global sensors or the existence of dynamic obstacles. Moreover, traditional motion control of wheeled mobile robots (WMRs) is achieved by using discontinuous control laws that are implemented through low level velocity PID controllers. Instead of using such methods, this work proposes to use local MPC as a useful methodology for WMR navigation under dynamic environments or as obstacle avoidance strategy. In this way, the desirable path coordinates are used in the control law as a way for obtaining the robot speed commands. Therefore, simulation results are used for addressing online MPC implementations. The system is on-robot tested by using simple on board perception systems. In this context, a local occupancy grid is built by using dead-reckoning and monocular data.

WM6.2  P0357  1350 - 1410
A Robust Downward-Looking Camera Based Velocity Estimation with Height Compensation for Mobile Robots
Xiaojing SONG, Kaspar ALTHOEFER, Lakmal D SENEVIRATNE
King's College London

Slip plays a vital role in traction control when a mobile robot traverses over soft soils. To estimate slip parameters, accurate measurement of robot velocity is particularly required. Previous related work done by the authors has adopted a single downward-looking single camera system for velocity and slip estimation [1][2]; however, such a single camera system is prone to lose accuracy when the distance between the camera and terrain is time-varying, such as traversing over uneven terrains [1]. To cope with
the problem, this paper presents a robust downward-looking camera based velocity estimation approach, which can particularly be capable of identifying height variation and compensating for velocity estimation. A downward-looking stereo camera instead of previously used single camera is adopted. The camera-terrain distance can be estimated by matching same features in left and right frames. Robot velocity measured with height compensation can be more accurate, compared to estimates without it. The proposed approach has been validated through comprehensive experimental study on a lab-based test rig; and test results show good performance of the proposed approach. With the proposed method, slip estimation techniques given by [2][3] can be promisingly extended to non-flat terrains.

WM6.3 P0553 1410 - 1430
Neuro-Fuzzy Based Autonomous Mobile Robot Navigation System
Maulin M JOSHI, *Mukesh A ZAVERI
Sarvajankan College of Engineering and Technology, Surat
*Sardar Vallabhbhai National Institute of Technology, Surat

Neuro-fuzzy systems have been used in past years for robot navigation applications because of their ability to learn human expertise and to utilize this knowledge to develop autonomous navigation strategies. In this paper, neuro-fuzzy based systems are developed for behavior based control of a mobile robot for reactive navigation. The proposed systems transform sensors’ input to yield wheel velocities. Novel algorithms are proposed for a) to find the range of the mobile robots from nearby obstacles and b) to generate training pairs for neural network, optimally. With a view to ascertain the efficacy of proposed system; developed neurofuzzy system’s performance is compared to neural and fuzzy based approaches. Simulation results show effectiveness of proposed system in all kind of obstacle environments.

WM6.4 P0795 1430 - 1450
An Effective Collaborating Algorithm for Swarm Robots Communicating by Sematectonic Stigmergy
Tuan A PHAN, R. Andrew RUSSELL
Monash University, Melbourne

This paper investigates an algorithm, which improves the task completion rate for simple swarm robots implementing a leaf-curling task. In this biologically inspired task, robots collaborate to find a suitable place to bend a leaf, which allows them to successfully fold it up. To complete the task simple robots were developed that are not equipped with any direct communication devices. They communicate via sematectonic stigmergy, which means every robot can only gain information via changes in their working environment, which are made by other robots. This type of communication has proved beneficial in helping swarm robots monitor the performance of other swarm members without direct contact, team mate localization or recognition. However, in earlier experiments, implementing the leaf-curling task, information perceived by every robot has not been effectively used to create meaningful collaboration. This disadvantage becomes evident via the low task completion rate. If robots explore their environment, this will improve the outcome by increasing the probability of finding the most suitable part of the leaf to work on. In this paper, an algorithm enabling swarm robots to effectively explore the environment and find the most effective place to perform the leaf-curling task is described in detail. The improvement of completion rate, achieved by this exploring rule, is verified by both simulation and physical experiments with a group of W-AntBots.

WM6.5 P0908 1450 - 1510
X-band Radar Based SLAM in Singapore's Offshore Environment
John MULLANE, *Samuel KELLER, Akshay RAO, Martin David ADAMS, **Anthony YEO, ***Franz S. HOVER, ***Nicholas M PATRIKALAKIS
Nanyang Technological University
*Swiss Federal Institute of Technology
**National University of Singapore
***Massachusetts Institute of Technology

This paper presents a simultaneous localisation and mapping (SLAM) algorithm implemented on an autonomous sea kayak with a commercial off-the-shelf X-band marine radar mounted. The Autonomous Surface Craft (ASC) was driven in an off-shore test site in Singapore's southern Selat Puah marine environment. Data from the radar, GPS and an inexpensive single-axis gyro data were logged by an on-board processing unit as the ASC traversed the environment, which comprised geographical and surface vessel landmarks. An automated feature extraction routine is presented, based on a probabilistic landmark detector, followed by a clustering and centroid approximation approach. With restrictive feature modeling, and a lack of vehicle control input information, it is demonstrated that via the novel RB-PHD-SLAM Filter, useful results can be obtained, despite an actively rolling and pitching ASC on the sea surface. In addition, the merits of investigating ASC SLAM are demonstrated, particularly with respect to the map estimation, obstacle avoidance and target tracking problems. Despite the presence of GPS and gyro data, heading information on such small ASCs is greatly compromised which induces large sensing error, further accentuate by the large range of the radar sensor. This work is a step towards realising an ASC capable of performing environmental or security surveillance and reporting a real-time active awareness of the above-water scene.
Nanyang Technological University

In this paper, we consider leader-based shape coordination for multi-robot systems. It is shown that having knowledge about desired velocity and effective interaction among individuals can help group members to continue the path even after leader failure. Since any collective behavior emerges from interaction among individuals, we propose interactive force to maintain minimum distance among agents as well as group unity during movement even after leader failure. Simulation results are presented to illustrate the performance of proposed method.

Session WM7

Date: Wednesday, 08 December 2010
Time: 1330 - 1530
Venue: Oriole

Localization, Navigation and Mapping I

Chairs: Keck Voon LING
Nanyang Technological University

WM7.1 P0320 1330 - 1350
SLAM with Salient Line Feature Extraction in Indoor Environments
Su-Yong AN, Jeong-Gwan KANG, Lae-Kyoung LEE, Se-Young OH
Pohang University of Science and Technology

This paper presents a simultaneous localization and mapping (SLAM) of a large indoor environment using Rao-Blackwellized particle filter (RBPF) along with line segments as the landmarks. To represent the environment as a compact form, we use only two end points of the line segment, reducing computational cost in modeling line uncertainty. With a modified scan point clustering method, the proposed adaptive iterative end point fitting (IEPF) plays an important role in estimating line parameters by taking a noisy scan point near end points into account. Thus, by line-segment matching the robot is localized well in a local frame. We also introduce an online global optimization of a map, which provides more consistent map by removing spurious lines and merging collinear lines. Each of our approaches is efficiently integrated into the proposed RBPFSLAM framework. Experiments with well-known data set demonstrate that the proposed method provides a reliable SLAM performance along with a compact map representation.

WM7.2 P0475 1350 - 1410
Role-Based Path Planning and Task Allocation with Exploration Tradeoff for UAVs
Christoph RASCHE, Claudius STERN, Lisa KLEINJOHANN, Bernd KLEINJOHANN
University of Paderborn

After large accidents or natural disasters a fast and efficient retrieval of injured is required. With recent advances, unmanned aerial vehicles (UAVs) are more and more a viable choice under such circumstances. The problem of coordination arises with the number of employed UAVs as well as proper task allocation among possibly heterogeneous UAVs. In this work a hybrid approach for UAV coordination and task allocation is presented. It covers the exploration of unknown terrains as well as role-based, goal-oriented path planning and simultaneous task allocation. The approach uses a role system to support prioritized task assignment and an informed search algorithm to find consistent trajectories to known goal positions. The system is suited for highly dynamic environments, requiring frequent recalculations.
This paper is concerned with the Simultaneous Localization And Mapping (SLAM) application with a mobile robot moving in a structured environment using data obtained from rotating sensors such as radars or lasers. A line-based EKF-SLAM (EKF stands for Extended Kalman Filter) algorithm is presented, which is able to deal with data that cannot be considered instantaneous when compared with the dynamics of the vehicle. When the sensor motion is fast relative to the measurement time, scans become locally distorted. A mapping solution is presented, that includes sensor motion in the observation model by taking into account the dynamics of the system. Experimental results with real-world 2D-laser scanner data are presented. Moreover a performance evaluation of the results is carried out. A quantitative performance evaluation method is proposed when dealing with a 2D line map and when a ground truth is available. It is based on the bipartite graph matching and combines several criteria that are described. A comparative study is made between the output data of the proposed method and the data processed without taking into account distortion phenomena.

This paper first demonstrates an interesting property of bundle adjustment (BA), "scale drift correction". Here "scale drift correction" means that BA can converge to the correct solution (up to a scale) even if the initial values of the camera pose translations and point feature positions are calculated using very different scale factors. This property together with other properties of BA makes it the best approach for monocular Simultaneous Localization and Mapping (SLAM), without considering the computational complexity. This naturally leads to the idea of using local BA and map joining to solve large-scale monocular SLAM problem, which is proposed in this paper. The local maps are built through Scale-Invariant Feature Transform (SIFT) for feature detection and matching, random sample consensus (RANSAC) paradigm at different levels for robust outlier removal, and BA for optimization. To reduce the computational cost of the large-scale map building, the features in each local map are judiciously selected and then the local maps are combined using a recently developed 3D map joining algorithm. The proposed large-scale monocular SLAM algorithm is evaluated using a publicly available dataset with centimeter-level ground truth.

This vehicle's localization is classically achieved by Bayesian methods like Extended Kalman Filtering. Such a method provides an estimated position with its associated uncertainty. Bounded-error approaches using interval analysis work in a different way as they provide a possible set of positions. An advantage of such approaches is that the results are guaranteed and are not probabilistically defined. This paper focuses on constraints propagation techniques using static and dynamic fusion. Static fusion uses data redundancy to enhanced proprioceptive data. Then dynamic fusion uses GPS in order to reduce the size of the localization box. The approach has been validated with a real outdoor vehicle.

In a wireless sensor network nodes can be deployed randomly to collect data from an area of interest. So it is mandatory for each node in the network to be aware of its location in the physical world, in order to map the collected information to the base station. Thus, localization becomes an important technique in sensor networks. Further, power conservation is also an important factor as the nodes are operated with limited battery supply. Hence to increase the lifetime of the network, an energy-efficient localization is required. In this paper, a fine-grained paradigm of localizing sensor nodes based on Received Signal Strength (RSS) under controlled power of anchor nodes is proposed. The transmission power control is achieved by Distance Controlled Transmission Power (DCTP) adjustment algorithm where an anchor node closer to an unknown node operates at low transmission power while the one at farther distance operate at high transmission power. Thus based on the distance of the unknown node with anchor node, the power conservation is also an important factor as the nodes are operated with limited battery supply. Hence to increase the lifetime of the network, an energy-efficient localization is required. In this paper, a fine-grained paradigm of localizing sensor nodes based on Received Signal Strength (RSS) under controlled power of anchor nodes is proposed. The transmission power control is achieved by Distance Controlled Transmission Power (DCTP) adjustment algorithm where an anchor node closer to an unknown node operates at low transmission power while the one at farther distance operate at high transmission power. Thus based on the distance of the unknown node with anchor node, the transmission power level of anchor is adjusted. This paper also provides analysis of the impact of various transmission power levels on the proposed localization algorithm. Simulation analysis is carried out in Matlab and the results show the performance of the algorithm in terms of localization accuracy and power consumption.
Session WM8
Date: Wednesday, 08 December 2010
Time: 1330 - 1530
Venue: Bluebird

**Human Centered Systems**

Chairs: Jean-Yves FOURQUET

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**WM8.1 P0691 1330 - 1350**

A Haptic Training Environment for the Heart Myoblast Cell Injection Procedure

Vu Thanh LE, Saied NAHAVANDI, Doug CREIGHTON

Deakin University

The heart muscle of a cardiac arrest victim continues to accumulate damage throughout its lifetime. This reduces the heart’s ability to pump sufficient oxygen and nutrient blood to meet the body’s needs. Medical researchers have shown that direct injection of pre-harvested skeletal myoblast cells into the heart can restore some muscle function [1]. This operative procedure usually necessitates the surgeon to open a patient’s chest. The open chest procedure is usually a lengthy process and often extends the recovery time of the patient. Alternatively, a high accuracy surgical aid robotic system can be used to assist the thoracoscopic surgery [2][3]. While the robotic surgical method aids faster patient recovery, a less experienced surgeon can potentially cause damage to surrounding tissue. This paper presents a study into the development of a virtual haptically-enabled heart myoblast injection simulation environment, which can be used to train new surgeons to get hands on experience with the process. The paper also discusses the development of a generic constraint motion technique for needle insertion. Experiments on human performance measures and efficacy, while interacting with haptic feedback training models, are also presented. The experiment involved 10 operators, with each person repeating the needle insertion and injection 10 times. A notable improvement in the task execution time with the number of repetitions was observed. Operators improved their time by up to 300% compared to their first training attempt for a static heart scenario. Under a dynamic heart motion, operator’s performance was slightly lower, with the successful rate of completing the experiment reduced from 84% to 75%.

**WM8.2 P0539 1350 - 1410**

Hierarchical Learning Approach for One-shot Action Imitation in Humanoid Robots

Yan WU, Yiannis DEMIRIS

Imperial College, London

We consider the issue of segmenting an action in the learning phase into a logical set of smaller primitives in order to construct a generative model for imitation learning using a hierarchical approach. Our proposed framework, addressing the "how-to” question in imitation, is based on a one-shot imitation learning algorithm. It incorporates segmentation of a demonstrated template into a series of subactions and takes a hierarchical approach to generate the task action by using a finite state machine in a generative way. Two sets of experiments have been conducted to evaluate the performance of the framework, both statistically and in practice, through playing a tic-tac-toe game. The experiments demonstrate that the proposed framework can effectively improve the performance of the one-shot learning algorithm and reduce the size of primitive space, without compromising the learning quality.

**WM8.3 P0661 1410 - 1430**

Saliency Ranking for Benthic Survey using Underwater Images

Matthew JOHNSON-ROBERSON, *Oscar PIZARRO,* Stefan WILLIAMS

KTH Royal Institute of Technology

*The University of Sydney

This paper presents a novel architecture for a classification system based on the visual saliency of images. The work is motivated by the difficulty of reviewing large numbers of images as a human operator in the context of Autonomous Underwater Vehicle (AUV) surveys. We formulate a feature space in which an algorithm operates over color and texture to determine saliency and illustrate how this can be used to find interesting or unusual images within a large data set. The saliency classification based on these general image features allows for overlays highlighting interesting benthos or geologic structures on large scale 3D seafloor reconstructions, quickly providing spatial context to human observers. These results are validated using a set of human trials in which images are classified into salient and non-salient categories by a number of test subjects. The trials show good agreement both between subjects and between the human labels and the automated classification system. The results of the automated technique are also compared directly to a more traditional SVM classification system showing favorable results for our system for generalizing to new environments.

**WM8.4 P0965 1430 - 1450**

On the Collaboration of an Automatic Path-planner and a Human User for Path-Finding in Virtual Industrial Scenes

Nicolas LADEVEZE, Jean-Yves FOURQUET

ENIT

This paper describes a global interactive framework enabling an automatic path-planner and a user to collaborate for finding a path in cluttered virtual environments. First, a collaborative architecture including the user and the planner is described. Then, for real time purpose, a motion planner divided into different steps is presented. First, a preliminary workspace discretization is done without time limitations at the beginning of the simulation. Then, using these pre-computed data, a
second algorithm finds a collision free path in real time. Once the path is found, an haptic artificial guidance on the path is provided to the user. The user can then influence the planner by not following the path and automatically order a new path research. The performances are measured on tests based on assembly simulation in CAD scenes.

**WM8.5 P0969 1450 - 1510**
**Automatic Gait Characterization for a Mobility Assistance System**
Cong ZONG, Mohamed CHETOUANI, *Adriana TAPUS Université Pierre et Marie Curie
*Ecole Nationale Supérieure de Techniques Avancées

This paper addresses gait analysis for a mobility assistance robot designed for the elderly people. Six patients and ten healthy peoples were invited to be part of our first pilot experiment. We designed two experiments so as to firstly detect gait parameters and secondly to identify a change of speed. For the first trial, we compared the temporal-distance parameters of the healthy people and of individuals suffering of mobility problems. The percentages of the gait cycle for duration of stance are higher for people with mobility impairment than for healthy people. In the second experiment, we detected the change in walking speed from the ten healthy peoples. Two different metrics derived from the Kullback-Leibler (KL) divergence and from the Generalized Likelihood Ratio (GLR) were employed for walking change detection. The Receiver Operating Characteristic (ROC) curves show a better performance for the signal obtained with the accelerometer sensor than that obtained with the infrared distance sensor. Nevertheless, the results of our experiments demonstrated that both methodologies (KL and GLR) can be used to detect the change points during walking at high or slow speed.

**WP2.1 P0616 1620 - 1640**
**An Unscented Kalman Filtering Approach for Nonlinear Singular Systems**
Shuwen PAN, Hongye SU, Zhitao LIU, *Pu LI Zhejiang University
*The Technical University of Ilmenau

In this study, an unscented Kalman filtering approach is proposed for nonlinear singular systems to obtain not only the estimation for the states but also for the unknown inputs presented in the measurement equations. No prior information is needed for the unknown inputs to be estimated. The formulation of the proposed approach is based on the weighted least squares estimation (LSE) and the unscented transformation (UT) methods. The restriction of the proposed approach is also mentioned. An illustrative example demonstrates that accurate and consistent state and unknown input estimations are obtained with the proposed approach.

**WP2.2 P0760 1640 - 1700**
**Identification of Wiener Systems based on Fixed Point Theory**
Guoqi LI, Changyun WEN Nanyang Technological University

In this paper, we propose a new method for the identification of Wiener systems based on fixed point theory. The linear part of the system is an infinite impulse response (IIR) system and the nonlinear static function is allowed to be non-continuous or non-smooth. Our proposed technique transforms the estimation of parameters to finding a fixed point of a nonlinear equation. We show the existence of the fixed point and also develop an iterative algorithm to find the fixed point. It is proved that, the determined fixed point is actually a global minimum point of the cost function and it is unique, and thus global convergence of the estimates is ensured. The performance of the proposed approach is illustrated by simulation studies.

**WP2.3 P0867 1700 - 1720**
**Robust Tracking in Mixed LOS/NLOS Environments**
Lili YI, Chin-heng LIM, *Chong-Meng SEE, Sirajudeen GULAM RAZUL, Zhiping LIN Nanyang Technological University
Non-line-of-sight (NLOS) error is one of the most important factors affecting the accuracy of positioning or tracking especially in urban or indoor environments. This paper concentrates on alleviating the influence of the NLOS error. A position detection approach utilizing the circle error probability (CEP) in conjunction with the least square (LS) method and Kalman Filter (KF) tracking algorithms is proposed. The LS is used to estimate the positions of a moving target from time-of-arrival (TOA) measurements and the KF is used to smooth the tracking trajectory. Simulation results show that this approach can effectively identify line-of-sight (LOS) estimated positions, leading to higher tracking accuracy than that by other tracking methods without using position detection.

Convex Formulations for Data-Based Uncertainty Minimization of Linear Uncertainty Models
Kurt E HÄGGBLOM
Åbo Akademi University

Convex formulations are derived for the minimization of uncertainty bounds with respect to a nominal model and given input-output data for general uncertainty models of LFT type. The known data give rise to data-matching conditions that have to be satisfied. It is shown how these conditions, which originally are in the form of BMIs for a number of uncertainty models, can be transformed to LMIs, thus making the optimization problem convex. These formulations make it easy to find the best uncertainty model from a number of alternatives for robust control design.

Noise Covariance Estimation using Dual Estimation for Disturbance Storm Time Index Application
Boonsri KAEWKHAM-AI, Kasemsak UTHAICHANA
Chiang Mai University

The disturbance storm time (Dst) index is used for predicting the geomagnetic storm that can affect many systems on earth. The application of the dual unscented Kalman filter (DUKF) to improve the quality of the Dst index prediction by simultaneously estimating the process noise covariance is set forth in this paper. In DUKF, two unscented Kalman filters (UKFs) are run in parallel. The UKF applied to a model-based Dst index prediction is so called a state estimator; while the other, a parameter estimator, is for identifying and recursively updating the process noise covariance. The performance comparison between the traditional UKF with fixed constant values of the process noise covariance, and the DUKF are examined. The actual all Dst and the Dst data during the storm (below -80 nT) are used to assess the quality of the predictions. It is found that root mean square error (RMSE) of Dst index prediction using the DUKF is lower than that of the UKF with fixed constant process noise covariances. Specifically, RMSEs of the DUKF are 6.5816 for all Dst and 18.0615 for Dst below -80 nT, whereas, the prediction using a fixed constant process noise covariance yield RMSEs of at least 6.6678 and 19.3954 for all Dst and Dst below -80 nT, respectively. Hence, the DUKF outperforms the traditional UKF with fixed constant process noise covariances in this study.
WP3.1 P0381 1620 - 1640
Stability of Complex Systems with Mixed Connection Configurations under Shared Control
Tri TRAN, Hung T. NGUYEN, Q P HA
University of Technology, Sydney

This paper presents a new stabilizing method for the control of complex systems operating in semi-automatic modes. The complex system is modeled by several spatially-coupled subsystems interconnected in parallel, serial and cycle configurations. Each subsystem is regulated by a dedicated autonomous controller that also allows for a manual control mode. An interconnection stability condition which takes the couplings between subsystems into consideration is derived from the renowned dissipative systems theory. Built upon this stability condition, decentralized stabilizing agents for autonomous controllers are subsequently deployed independently and segregatedly from the control algorithms. Due to this independence, human errors from manmachine interactions, that may destabilize the control systems, can be avoided; also different types of control algorithms and controllers of subsystems are interoperable with the same stabilizing mechanism. To accomplish such tasks simultaneously, the stabilizing agents render overriding outputs for the automatic controllers, and at the same time, provide instability warning signals and manipulation guidance to the operators to successfully regulate the subsystems in the manual control mode, yet maintain the plant-wide stability. Real-time data of control inputs and plant outputs is exerted under the auspices of controller dissipativity indices and trajectories to stabilize the systems with closed-loop control and man-in-the-loop coexistence. Our main results are illustrated in simulation for a three-unit system.

WP3.2 P0156 1640 - 1700
Controllability of Fractional Impulsive Neutral Functional Integrodifferential Inclusions with Infinite Delay in Banach Spaces
Zhixin TAI, *Xingcheng WANG
Bohai University
*Dalian Maritime University

In this work the controllability of fractional impulsive neutral functional integrodifferential inclusions in a Banach space has been addressed. Sufficient conditions for the controllability are established using fractional calculus, a semigroup of operators and fixed point theorem of Leray-Schauder nonlinear alternative.

WP3.3 P0600 1700 - 1720
Routing Strategy with Waiting Time on Scale-free Network
Dan WANG, Yan-Ping LI, Wenwei LIU, *Liang DONG, *Lin LI
Shenyang University
*Northeastern University

We study traffic dynamics and propose a new routing strategy based on the local topological information in scale-free network. According to the new routing strategy with a single tunable parameter, a packet is delivered to next node with probabilities that depend not only on the degrees of the next node but also the estimated waiting time at the new node. The routing algorithm is implemented in BA scale-free networks in the case of nodes’ delivering ability proportional to its degree. Simulations show that the maximal network capacity corresponds to an optimal controlled parameter.

WP3.4 P0966 1720 - 1740
Static Output Feedback Control for Continuous Descriptor Systems
Yu ZHENG, Jun-e FENG, Lin SUN, Juan YAO
Shandong University

The static output feedback control problem is investigated in this paper for continuous descriptor systems. New necessary and sufficient conditions are established to ensure the admissibility of the continuous descriptor systems. Then, based on the new necessary and sufficient conditions, sufficient conditions are derived for admissibility of the closed-loop systems. The desired static output feedback controllers can be derived directly via the cone complementarity linearization techniques. Finally, an illustrative example is presented to demonstrate the effectiveness of the proposed approach in this paper.

WP3.5 P0801 1740 - 1800
Active Sway Control of a Single Pendulum Gantry Crane System using Output-Delayed Feedback Control Technique
Rajeeb DEY, Nishant SINGHA, Priyanka CHAUDHARY, *Sandip GHOSH, **Goshaidas RAY
Sikkim Manipal University
*National Institute of Technology Rourkela
**Indian Institute of Technology, Kharagpur

This paper investigates the implementation of output-delayed feedback control (ODFC) technique for controlling the sway angle of single pendulum gantry crane (SPGC) system. Linearized mathematical model of the SPGC in state space form is considered for the investigation. The designed ODFC has undergone complete stability analysis for a given controller gain.
Session WP4 - Invited Session

Date: Wednesday, 08 December 2010
Time: 1620 - 1800
Venue: Kingfisher

Networked Systems

Chairs: Ling SHI
Hong Kong University of Science and Technology

WP4.1 P0403 1620 - 1640
Sensor Scheduling with Limited Communication Energy and Bandwidth
Ling SHI, *Peng CHENG, *Jiming CHEN
California Institute of Technology, Pasadena
*Zhejiang University

In this paper, we consider the problem of sensor scheduling with limited resources. Two sensors are used to measure the state of a discrete-time linear process. We assume that each sensor has a maximum duty cycle and at most one sensor can communicate with a remote estimator at each time step due to the limited communication bandwidth. When a sensor is scheduled to send data, it sends the most recent D measurement data to the estimator. Upon receiving the measurement data from the sensors, the estimator computes the optimal estimate of the state of the process. We first present a necessary condition for a sensor scheduling scheme to be optimal. Based on this necessary condition, we construct an optimal scheduling scheme that minimizes the estimation error at the estimator and at the same time satisfies the energy and communication bandwidth constraints. We also provide a sufficient condition on the minimum D such that an optimal scheduling scheme can be constructed. Examples are provided throughout the paper to demonstrate the results developed.

WP4.2 P0434 1640 - 1700
Feedback Stabilization over Stochastic Multiplicative Input Channels: Continuous-Time Case
Nan XIAO, Lihua XIE
Nanyang Technological University

The present work fits within the general study of communication and control co-design, where the mean square stabilization of continuous-time networked control systems over stochastic multiplicative input channels is addressed. Motivated by the limited communication capacity and network resource allocation in multiple channel communication systems, we assume that the overall quality of service defined in this paper is fixed and can be assigned among the input channels. We show that there exists a minimal requirement on the overall quality of service for achieving the mean square stabilization of the networked system. For the case of static state feedback, a tight lower bound on the overall quality of service for mean square stabilization is derived in terms of the instability degree of the plant. In the case of output feedback, additional limitations are induced by nonminimum phase zeros, where both stabilization over a single-input channel and stabilization of essentially triangular plants over multi-input channels are studied. The application of the results to vehicle platooning is demonstrated.

WP4.3 P0483 1700 - 1720
Graphic Interpretations of Structural Controllability for Switched Linear Systems
Xiaomeng LIU, Hai LIN, Benmei CHEN
National University of Singapore

This paper considers the controllability problem for switched linear systems. In particular, the structural controllability of switched linear systems is investigated. The structural controllability of switched linear systems is a generalization of the traditional controllability concept for dynamical systems, and purely based on the graphic topologies among state and input nodes. First, two kinds of graphic representations of switched linear systems are proposed. Second, several graphtheoretic characterizations of the structural controllability for switched linear systems are presented based on these two newly introduced graphs. Finally, the paper concludes with several illustrative examples and discussions of the results and future work.

WP4.4 P0825 1720 - 1740
Particle Filter Based Human Motion Tracking
Zhenning LI, Dana KULIC
University of Waterloo

This paper proposes a particle filter based markerless upper body motion capture system, capable of running in real-time. This system is designed for a humanoid robot application, and thus a monocular image sequence is used as input. We first set up a model of the human body, a sub-model which includes 11 Degrees of Freedom is used for the upper body tracking. Considering the real-time processing requirements, two time efficient cues are implemented in the likelihood calculation, namely the edge cue and the distance cue. The system is tested using a publicly available database, which consists of both the videos and the ground truth data, enabling quantitative error analysis. The system successfully tracks the human through arbitrary upper body motion at 20Hz.

WP4.5 P1069 1740 - 1800
Convergence and Mean Square Stability of Optimal Estimators for Systems with Measurement Packet Dropping
Huanshui ZHANG, Xinmin SONG, *Ling SHI
Shandong University
*Hong Kong University of Science and Technology

This paper is concerned with estimation problem for discrete-time systems with packet dropping. A new optimal filter is derived by minimizing the mean
squared estimation error. An optimal smoother is also derived in a similar way. Both estimators are designed by solving one deterministic Riccati equation. Both the convergence of the estimation error covariance and mean square stability of the estimator are proved under standard assumption. It is shown that the new estimator has smaller error covariance and has wider applications as compared with the MMSE estimator. One of the key techniques adopted in this paper is the introduction of the innovation sequence for the multiplicative noise systems.

Session WP5
Date: Wednesday, 08 December 2010
Time: 1620 - 1800
Venue: Nightingale
Search, Rescue and Field Robotics
Chairs: Jose M GIRON-SIERRA
Universidad Complutense de Madrid
Vijay S RAJPUROHIT
Gogte Institute of Technology
Belgaum

WP5.1  P0265  1620 - 1640
Chiemela ONUNKA, *Glen BRIGHT
University of Kwazulu Natal
*University of kwazulu Natal

Technological advancements over the years have increased the use of Radar technology in the field of robotics, especially in marine robotics to aid obstacle detection algorithms. Obstacle detection comprises of an analytical process in which different algorithms are applied to the field of study to determine the range of objects that are within the reach of a robot. Radar signal analysis and target detection in conjunction with target tracking are attributes required for autonomous marine navigation. The paper presents a model which converts optimal estimates of radar range values for each range spectra into multiple targets down-range and also presents an approach for power range spectra (range bins) prediction using the radar range equation with adequate information of the signal-to-noise ratio (SNR) of the radar. Obstacle detection in the presence of noise raises certain probabilities of false alarms. Target characteristics are simulated and these are fluctuating targets and non-fluctuating targets. Analytical models, simulations and techniques of obstacle detection for autonomous marine craft navigation using a continuous wave radar system were points of discussion in the paper.

WP5.2  P0423  1640 - 1700
A Development Project of Autonomous Marine Surface Vehicles for Sea Demining
Fernando J PEREDA, Hector GARCIA DE MARINA,
Juan Francisco JIMENEZ, Jose M GIRON-SIERRA
Universidad Complutense de Madrid

A sea demining system using autonomous marine surface vehicles (AMSV) is introduced. The research involves the development of exemplars of these vehicles, and the procedures for area scanning and coverage. The demining is made by field influence, towing a submerged "fish". This study is made both with simulations and with scale experiments.

WP5.3  P0589  1700 - 1720
Single-Human Multiple-Robot Systems for
Urban Search and Rescue - Justifications, Design and Testing
Choon Yue WONG, Gerald SEET, Siang Kok SIM, Wee Ching PANG
Nanyang Technological University

The evolution of interactions between humans and robots has reached a stage close to where multiple robots can be robustly deployed. The domain of Urban Search and Rescue stands to benefit from such a capability. However, even autonomous robots must be supervised by humans. Yet, reasons such as economy, efficiency, added reliability as well as improving overall group capability and addressing payload constraints, make multiple robot deployment (MRD) an appealing possibility. Single-Human Multiple Robot Systems facilitate MRD while ensuring the supervision of robots deployed. However, the design of the single-human multiple-robot system requires consideration of key design attributes such as collective size, composition and structure as well as of the MRD issues of communication costs, computational costs, cognitive workload and situation awareness. The experiments to determine the effects of the key design attributes on the issues of MRD have been designed and are described in this paper as well.

WP5.4   P0602   1720 - 1740
A Motion Controller for a Pan-tilt Camera on an Autonomous Helicopter
Haibo DENG, Xiaoguang ZHAO, Zengguang HOU
Chinese Academy of Sciences

In this paper, a motion controller for a pan-tilt camera mounted on an autonomous helicopter is presented. The motion planner is designed according to the kinematics of the pan-tilt camera. However, the solution of the inverse kinematics of the pan-tilt camera is not unique. To deal with this situation, a decision maker is designed. The decision maker makes use of a cost function to decide which solution should be chose. And the error signal is defined as the difference between pan-tilt joint angles and the desired joint angles. The dynamics of the error system is derived, and proportional controllers are designed according to the error dynamics to control the pan and tilt joints respectively. This system is validated in a virtual reality environment, and the simulation results show that this system can track the target successfully.

WP5.5   P0951   1740 - 1800
The Use of Area Extended Particle Swarm Optimization (AEPSO) in Swarm Robotics
Adham ATYABI, David M W POWERS
Flinders University

Swarm Robotics is the study of simple, unintelligent robots teaming up together to address complicated tasks using cooperation and knowledge/skills sharing factors. Particle Swarm Optimization (PSO) is an Evolutionary algorithm inspired by animals’ social behaviors. PSO has been used in various problems due to its fast convergence capability. Area Extended PSO (AEPSO) is an enhanced version of PSO designed to address complications in the Swarm Robotics field. These complications include dynamicity of the environment, degree of cooperation, time dependency of the tasks, and uncertain nature of the environment. This study investigates advantages and shortcomings of the AEPSO method in the robotic domain.
In this paper, a jumping motion is considered with the goal of achieving high-speed dynamic motion for legged robots. We propose a two-step jumping pattern which makes use of the characteristic of a lightweight and fast actuator. In addition, jumping strategies based on the dynamics of the robots are presented, and the effect of structural parameter on jumping height is analyzed. Experimental results are shown in which a 1-DOF two-legged robot jumps with three patterns.

WP6.4 P0780 1720 - 1740
Neuro-adaptive Virtual Leader Based Formation Control of Multi-Unmanned Ground Vehicles
Zan YAO, Yongduan SONG, Wenchuan CAI
Beijing Jiaotong University

The problem of formation control of multiple unmanned ground vehicles (UGVs) is studied in this paper. The underlying problem is essentially a high dimensional multi-vehicle trajectory tracking control problem, its complexity grows significantly as the number of the involved vehicles increases. To address the singularity inherent in regular formation process and the complexity involved in formation of multiple vehicles, this paper attempts an approach that integrates robust adaptive neural network (NN) control with the virtual leader concept. The fundamental idea behind this approach is to use the virtual leader-follower format to convert the problem into the one that only involves each individual vehicle to track the virtual leader. By doing so, the singularity associated with the traditional formation control is also avoided. As the system involves significant nonlinearities and uncertainties, robust adaptive NN control algorithms are developed, which are shown to be able to achieve high precision formation. The feasibility and effectiveness of the proposed method are also verified by simulation studies.

WP6.5 P0272 1740 - 1800
Survey Results on Status, Needs and Perspectives for using Mobile Service Robots in Industrial Applications
Andreas KROLL, Samuel SOLDAN
University of Kassel
Mobile robots for carrying out service tasks in industrial plants and on infrastructure gain importance e.g. due to aging assets and demographics. In order to identify key areas requiring research and development activities, a questionnaire-based online survey was conducted in 2009. Addressed were participants working in industry knowing best about needs, potentials, obstacles and pitfalls of applying mobile service robots in their companies/industrial sector. This paper presents the surveying methods and the obtained results which mainly cover chemical and automotive industries due to their world-wide economic significance as well as their research and innovation intensity.

**Session WP7 - Invited Session**

**Date**: Wednesday, 08 December 2010  
**Time**: 1620 - 1800  
**Venue**: Oriole

**Advances in Biometric Theory and Applications II**

**Chairs**: Massimo TISTARELLI  
University of Sassari  
Wei Yun YAU  
Institute for Infocomm Research

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**WP7.1 P0735 1620 - 1640**

**Face Occlusion Detection by using B-spline Active Contour and Skin Color Information**

*Gahyun KIM, Jae Kyu SUHR, Ho Gi JUNG, Jaihie KIM*  
Yonsei University

This paper proposes a face occlusion verification method for an automated teller machine (ATM) application. The proposed method mainly consists of three steps. Firstly, a head and shoulder shape is detected by applying B-spline active contour to motion edges. This motion edge is generated by a kurtosis-based frame selection and distance transformation-based motion edge detection. Secondly, a face area is estimated by fitting an ellipse to the detected head and shoulder shape. Finally, occlusion of the face area is determined by measuring skin color area ratio (SCAR) of whole face area and facial component areas. Experimental results show that the proposed head and shoulder detection method has 94.8% detection rate even though there are various types of severe occlusions in faces, and the proposed occlusion verifier has 86.7% verification rate.

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**WP7.2 P1121 1640 - 1700**

**Eye Feature Extraction using K-means Clustering for Low Illumination and Iris Color Variety**

*Van Huan NGUYEN, Thi Hai Binh NGUYEN, Hakil KIM*  
Inha University

This paper presents an approach for locating eye features in color images based on the unsupervised K-means clustering. Given the assumption that the input is an eye window containing a single eye, the proposed method detects the iris by unsupervised K-means clustering on the feature spaces of compensated red and green color channels. The iris circle is then refined using the gradient information and circular Hough transform. For the sclera detection, the r-g and r-b are utilized as they show the discriminant feature of sclera regardless of light condition and iris color. The sclera is then extended to fit the eyelids by a region growing scheme. Experiments on a collection of eye images extracted from FERET facial database and our self-collected images show a promising performance toward the low illumination and iris color variety.
A Comprehensive Sclera Image Quality Measure

Zhi ZHOU, Yingzi, Eliza DU, N. Luke THOMAS
Indiana University-Purdue University Indianapolis

Sclera recognition can be used for human identification. However, if the sclera images cannot be properly segmented by the system or the images of sclera patterns are defocused and/or saturated, it can significantly affect the accuracy of sclera recognition. In this paper, we propose a comprehensive sclera image quality measure which can quickly detect if the image has a valid eye, assess the image quality, evaluate the segmentation accuracy, and measure if the image has sufficient feature information for recognition. In addition, it used Dempster Shafer Theory to fuse the quality score, segmentation score, and feature score together to generate the overall combination score. It is empirically verified using the UBIRIS database that the proposed quality measure is highly correlated with the performance of sclera recognition.

Effects of Facial Alignment for Age Estimation

Hee Lin WANG, Jian-Gang WANG, Wei Yun YAU, *Xing Lun CHUA, *Yap-Peng TAN
Institute for Infocomm Research
*Nanyang Technological University

Age estimation is an important enabling capability for the near future, especially in applications related to Human Computer Interaction. Perhaps due to technical difficulties, age estimation has only recently begun to receive more attention. One of the more important pre-processing steps before age estimation is facial alignment, which spatially transforms a face image to align certain facial features, in order to maximize classification accuracy. However, the capability for facial alignment in automated age estimation literature is commonly assumed, and the effects of facial alignment is not addressed, even though it is an important issue especially for live deployment. In this paper, we present, to our knowledge, the results of the first systematic investigation on the effects of facial alignment on age estimation accuracy, and conclude with some directions on further topics of investigation in this area.

Speaker Gender Recognition using Score Level Fusion by AdaBoost

Waseda University
*Institute for Infocomm Research

We propose speaker gender recognition achieved by using score level fusion by AdaBoost. Soft biometrics has been focused on because recognition by fusing biometric systems and soft biometric traits may improve the accuracy of recognition and decrease the time for this. Gender recognition is important for speaker recognition and can provide important information to speaker recognition systems. Mel-frequency cepstral coefficient (MFCC) and pitch contain gender information. MFCCs and pitch are often used for gender recognition. Consequently, identification accuracy may be improved by using both MFCC and pitch. We focused on the score level fusion to accomplish speaker gender recognition. We propose speaker gender recognition based on the score level fusion using AdaBoost because it can control the recognition accuracy and recognition time. We experimentally demonstrate the proposed method's effectiveness through simulation results and show that it achieves greater accuracy than that obtained by using single information from voice.
Session WP8 - Invited Session
Date : Wednesday, 08 December 2010
Time : 1620 - 1800
Venue : Bluebird

**Advanced Concept for Emerging Computer Vision**

Chairs : Siu Yeung CHO
Nanyang Technological University

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**WP8.1 P1110 1620 - 1640**

**Two-tier Emergent Self-Organizing (TtEsom) Approach of Understanding Emotions**

Yok Yen NGUWI, *Teik Toe TEOH
James Cook University Australia, Singapore campus  
*Nanyang Technological University

This paper extends the previous work on emotion mapping [1] that attempts to emulate human brain reference model. Most emotion recognition system analyzes facial expression through supervised learning whereas this work adopts unsupervised learning. The system first locates the human face in an image, and then identifies the localized face emotion. The proposed method uses features obtained using Gabor wavelets, undergoes feature selection through the use of a derivation of Support Vector Machine. This work adopted a connectionist model, called Two-tier Emergent Self-Organizing Map (TtEsom) to analyse the emotion. The result shows improvement over the previous work and comparable result with supervised learning approach.

**WP8.2 P1106 1640 - 1700**

**A Segmentation based Approach for Shape Recovery from Multi-color Images**

M. K. M. RAHMAN, *Tommy W. S. CHOW, **Siu Yeung CHO
United International University  
*City University of Hong Kong  
**Nanyang Technological University

Conventional shape from shading (SFS) algorithms are unable to deal with multi-color image satisfactorily. This is because the assumption of constant surface albedo in the algorithms is not applicable to multi-color images. This paper proposes a new SFS approach for multi-color images through a segmentation-based shading recovery technique. With this technique a gray image is firstly extracted from the multi-color image containing better shading information compared with other color-to-gray conversion methods. The shading is recovered in the gray image as if the objects were made of single color. Shape of the multi-color object can then be recovered by classical gray-scaled SFS methods. Experimental results with synthetic and real multi-color images are presented. The obtained results corroborate that the proposed scheme is able to deliver better performance compared with other color SFS methods.

**WP8.3 P1108 1700 - 1720**

**A Color-based Approach for Disparity Refinement**

Raj Kumar GUPTA, Siu Yeung CHO  
Nanyang Technological University

We present a new disparity refinement algorithm that utilize color information of the reference image to generate sharp disparity maps. While existing methods use iterative approaches or require multiple disparity maps, the proposed algorithm uses a single pass approach to reduce errors at depth discontinuities. The experimental results are evaluated on the Middlebury benchmark dataset; show the effectiveness of the proposed algorithm.

**WP8.4 P1111 1720 - 1740**

**Emotion Indexing using Hidden Markov Expert Rule Model (HMER) for Autism Children**

Teik Toe TEOH, *Yok Yen NGUWI  
Nanyang Technological University  
*James Cook University Australia, Singapore campus

Hidden Markov Models (HHMs) have been applied successfully in the field of applied sciences and engineering [1]. The potential applications in manufacturing industries have not yet been fully exploited. In this paper, we propose a Hidden Markov Expert Rule Model (HMER) to index emotion as part of the assistive technology (AT). We propose to index 4 emotions: neutral, happy, sad and surprise. Numerical examples are given to illustrate the effectiveness of the proposed models. HMER is a part of AT that can be used to increase, maintain, or improve functional capabilities of individuals with difficulties in recognizing emotions. It promotes greater independence for this group of people by enabling them to perform task that they were formerly unable to accomplish. Children with autism spectrum disordered (ASD) have difficulty recognizing emotions in themselves and others. This work presents a fast cognitive assistive Hidden Markov-based emotional indexer which can help children with ASD to read and respond to the facial expressions of people they interacting with. The result of emotion indexer is very encouraging; it achieves accuracy of about 70% and the respond time is around 2 frames per seconds

**WP8.5 P1114 1740 - 1800**

**Fast Polar Harmonic Transforms**

Zhuo YANG, Sei-ichiro KAMATA  
Waseda University

Polar Harmonic Transform (PHT) is termed to represent a set of transforms those kernels are basic waves and harmonic in nature. PHTs consist of Polar Complex Exponential Transform (PCET), Polar Cosine Transform (PCT) and Polar Sine Transform (PST). They are proposed to represent invariant image patterns for two dimensional image retrieval and pattern recognition tasks. They are demonstrated to show superiorities comparing with other methods on describing rotation invariant patterns for images.

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References:


Kernel computation of PHTs is also simple and has no numerical stability issue. However in order to increase the computation speed, fast computation method is needed especially for real world applications like limited computing environments, large image databases and realtime systems. This paper presents Fast Polar Harmonic Transforms (FPHTs) including Fast Polar Complex Exponential Transform (FPCET), Fast Polar Cosine Transform (FPCT) and Fast Polar Sine Transform (FPST) that are deduced based on mathematical properties of trigonometric functions. The proposed FPHTs are averagely over 6~8 times faster than PHTs that significantly boost computation process. The experimental results on both synthetic and real data are given to illustrate the effectiveness of the proposed fast transforms.

Session WI
Date: Wednesday, 08 December 2010
Time: 1015 - 1800
Venue: Foyer

Interactive Session I

WI.1 P0309
Development and Application of Automation Control System to Plate Production Line
Zhi-jie JIAO, Chun-yu HE, Jun WANG, Zhong ZHAO
Northeastern University

The automation control system to plate production line is developed independently. The whole system is divided into several levels and control functions are put into effect by the basic automation system, process automation system and human-machine-interface (HMI) system. Plate production thickness accuracy depends on the Automatic Gauge Control (AGC) function in the basic automation system for the plate mill area. With date communication module, process tracking module, data management module, and model calculation module, the core process model setup function is implemented by process automation system. Process monitoring and operation are implemented by HMI system. This automation control system proposed here has been applied successfully to several plate production lines in China with a good effect.

WI.2 P0340
Passive Tracking using TDOA for Super-low-altitude Target
Panlong WU, Yuming BO, Jianshou KONG, Xingxiu LI
Nanjing University of Science and Technology

A novel near-space floating platform aided passive location method for super-low-altitude target using time difference of arrival (TDOA) is proposed. The new method uses a near-space floating platform as the baseline in the height to form a redundant location system consisting of several subsystems. Each subsystem can obtain a set of location results with ambiguity. After eliminating the ambiguity by the nearest matching, the new method can improve the location accuracy in the whole observed airspace by simplified weighted least square (SWLS) fusion. A better tracking performance can be achieved by treating the SWLS fusion location result as pseudo-linear measurement, and keeping the tracking through Kalman filter. Simulation results show that the proposed method comes to stabilization within 40s and has higher tracking precision than the SWLS method.

WI.3 P0414
Improvements of Flashing Mode by Programmed Control for Multiple Colors in LED Optical Stimulus System
Ken ISHII, Go TAKAYAMA, *Hiroshi INADA,
**Tomohiro MIKI, ***Makoto NARUMI, ***Yasunori SAKURAI**
Fisheries Research Agency
*Tokyo University of Marine Science and Technology
**Towa Denki Seisakusho Co., Ltd.
***Hokkaido University

Behavior observation examination of Japanese flying squid against optical stimulus is scheduled. A LED optical resource system has been designed as an optical stimulus for this examination. Two kinds of a LED driver and panel system were developed. One consists of constant current power supply units. The other is a LED driver based on Pulse Width Modulation (PWM). About the former, a control and monitor program via a personal computer (PC) was developed. In this paper, the former was described in detail. By control of two parameters of preset current and voltage to a constant current power supply unit, a waveform of LED current was improved. Leading-up time is shorter than nominal value. Overshoot was improved in comparison with a MOSFET switch control. Flashing worked in LED current higher than rated current value.

**WI.4**  **P0671**

Artificial Neural Network Based E-Nose and their Analytical Applications in Various Field

Maria JAMAL, *M R KHAN, *Saifyad A IMAM, **Arif JAMAL
GGS Indraprastha University
*Jamia Nagar,Okhla, New Delhi
**CPWD

A brief and historical overview of research and development in the field of artificial neural network based electronic nose system is presented. Electronic-nose devices have received considerable attention in the field of sensor technology during the past twenty years, largely due to the discovery of numerous applications derived from research in diverse fields of applied sciences. Electronic/artificial noses are being developed as systems for the automated detection and classification of odors, vapors, and gases. An electronic nose is generally composed of a chemical sensing system (e.g., sensor array or spectrometer) and a pattern recognition system (e.g., artificial neural network). We are developing electronic noses for the automated identification of volatile chemicals for environmental, medical applications, commercial industries, including the agricultural, biomedical, cosmetics, food, manufacturing, military, pharmaceutical, regulatory applications and various scientific research fields. This paper is a review of the major electronic nose technologies, developed since this specialized field was born and became prominent in the mid 1980s, and a summarization of some of the more important and useful applications that have been of greatest benefit to man.

**WI.5**  **P0767**

Dynamic Fuzzy Neural Network Based Predictive Control for Alternating Current

Excitation Generators
Zhifei ZHANG, *Xuan WANG
Foshan University of Science and Technology
*Guangdong University of Technology

Alternating current excitation generators (ACEG) can adjust the active power and inactive power flexibly and improve the stability of power system. The key to enhance the power system’s stability is to choose appropriate ACEG’s excitation control method. Conventional excitation controllers are unable to perform optimally over the full range of operation conditions and disturbances, due to the highly complex, non-linear nature of power systems. In this paper, dynamic fuzzy neural network based predictive control is proposed to cope with the problem. Fuzzy neural network is employed to predict power angle and stator voltage of ACEG excitation control system, in order to achieve good dynamics of fuzzy neural network, genetic algorithm is introduced to optimize network parameters. Based on the model output, branch-and-bound optimization method is adopted, which generates proper value of excitation control variable of ACEG. Fuzzy neural network based model predictive algorithm is used in internal model control scheme to compensate for process disturbances, measurement noise and modeling errors. Simulation test under large disturbance at various operating points is made. The results show the controller is effective and feasible.

**WI.6**  **P0982**

Equivalence and Stability of Two-layer Cellular Neural Network Solving Saint Venant 1D Equation

Vu Duc THAI, *Pham Thuong CAT
Thai Nguyen University
*Vietnam Academy of Science and Technology

Cellular Neural Network (CNN) has been used for solving Partial Differential Equations (PDE). However, the equivalence and stability of system should be considered carefully in a particular problem. In this paper, we introduce the model CNN for solving set of two PDEs describing water flow channels (called Saint Venant equation). We analyze the approximation and topological equivalence issues between Cellular Partial Difference Differential Equation (CPDDE) and its original PDEs. The stability of CNN system is also proved from discovering the equilibrium of the state and output of each cell. The paper has 4 parts. After introduction, part 2 gives a two-layered CNN 1D model for solving PDE Saint Venant equation. In the part 3 the equivalence and stability of the CNN model are proved, then simulation using FPGA. The conclusions are given in the last part.

**WI.7**  **P0361**

Interval Type-2 Non-Singleton Type-2 Takagi-Sugeno-Kang Fuzzy Logic Systems using the Hybrid Learning Mechanism Recursive-Least-Square and Back-Propagation Methods

Gerardo M. MENDEZ, Maria de los Angeles HERNANDEZ
Instituto Tecnologico de Nuevo Leon

This article presents a novel learning methodology based on the hybrid mechanism for training an interval type-2 non-singleton type-2 Takagi-Sugeno-Kang fuzzy logic systems (FLS). Using input-output data pairs during the forward pass of the training and prediction processes, the interval type-2 nonsingleton type-2 TSK FLS the consequent parameters were tuned by using the recursive least squares (RLS) method. In the backward pass, the antecedent parameters were tuned by using the backpropagation (BP) method. As reported in the literature, the performance indexes of these hybrid models have proved to be better than the individual training mechanism when used alone. The proposed hybrid methodology was tested thru the modeling and prediction of the steel strip temperature at the descaler box entry as rolled in an industrial hot strip mill. Results show that the proposed method compensates better for uncertain measurements than previous type-2 Takagi-Sugeno-Kang using non-hybrid or only back propagation learning mechanisms.

A Research on Parabolic Trough Solar Collector System Control based on Hedge Algebra

Nguyen Huu CONG, Ngo Kien TRUNG, Nguyen Tien DUY, Le Thi Thu HA
Thai Nguyen University of Technology

This paper presents a new method in controlling a parabolic trough solar collector system to improve the efficiency of the solar-to-thermal energy. It is designing an intelligent pre-processor using Hedge Algebra algorithm to calculate the setpoint for the control loop, in which besides the information about the trajectory calculated by a software, wind speed and fluid temperature of the collector are included. Moreover, this paper introduces a new simple flexible calculation tool which enables to calculate with a higher accuracy.

A Study on Tracking Position Control of an Pneumatic System by Backstepping Design

Chia-Hua LU, Yean-Ren HWANG
National Central University

The pneumatic actuator is widely used in industrial applications due to its reliability, low cost and no overheating problem in an industrial servo system. Recently, the development of control technology is improving and the requirement for control precision gets higher than before. In order to accomplish accurately control performance, nonlinear control techniques are implemented on control system. This paper presents a new form of backstepping sliding mode controller for X-Y table motion system. Experimental results are presented to show that the proposed controller can accomplish accurate tracking circle trajectory performance.

Reactive Power-Voltage Integrated Control Method based on MCR

Jin TAO, Jun WANG, Li WAN, *Dan CHEN, *Xiaosheng HUANG, **Wenjun ZENG
Electrical Power Test and Research Institute of Hubei
*Nanning Power Supply Company
**Wuhan University

In power system, the voltage pulsation and deficiency or surplus of reactive power will have a great effect on the quality of electric power supply. Through the appropriate and effective way of compensation, we can keep the balance of reactive power in the maximum degree by the maintenance of acceptable voltage. That’s to say, quality of power supply can be improved greatly by the synthetic compensation of reactive power and voltage. This paper firstly describes the principle of synthetic compensation of reactive power and voltage, then introduces the analyzes the principle of magnetically controlled reactor-MCR in detail and derives the characteristics, lastly designs a controlling strategy of reactive power and voltage based on MCR, so as to achieve the goal of dynamic reactive power compensation.

A Generic Procedure for Troubleshooting of PLC Based Control Systems

Ghazi Brotha Power House Attock
*University of Engineering and Technology, Taxila

This paper describes the problems generally faced with PLC based control systems and a general procedure to solve them. Flowcharts for troubleshooting of power supply faults, internal and external problems of PLC has been included in the paper. The approach mentioned for troubleshooting is general and can be applied on any type of PLC based control system. A case study is included to validate the developed general procedure for the trouble shooting of PLC based controlled system.

Impulsive Disturbance Rejection in Hard Disk Drives

Tingting GAO, *Chunling DU, Lihua XIE, Wen-Jian CAI
Nanyang Technological University
*Data Storage Institute

This paper proposes filtering methods to cancel the impulsive disturbance contained in position error signal (PES) in hard disk drives (HDDs). The impulsive disturbances may be observed as a few single sudden changes or some consecutive changes in PES. The filtering includes impulsive disturbance identification and estimation. A recursive method is used to determine the dynamic boundaries for identification. Two methods are proposed for estimation: a linear interpolation and an adaptive
least mean square (LMS) algorithm. The former is used to estimate the normal PES directly and the later is used to estimate the impulse disturbance for cancellation. It turns out that these methods are able to effectively cancel the impulse disturbance and do not affect the servo performance.

**WI.13 P0874**
**Optimal Control for EHA-VPVM System based on Feedback Linearization Theory**
*Ye ZHANG, Yongling FU, Weixing ZHOU*  
Beihang University

In this paper, an optimal control method based on feedback linearization is proposed for EHA-VPVM (electro-hydrostatic actuator with variable pump displacement and variable motor speed) system, which is a dual-input single-output (DISO) nonlinear system with multiplicative nonlinear property. In this work, a real EHA-VPVM system is modeled at first. Then the nonlinear model is linearized through feedback linearization and a control method is designed by using optimal control theory based on the linearized model. Simulation results show that our control method is effective for EHA-VPVM position control system, and can suppress perturbation of external load force to some degree. In addition, by simply adjusting the weighting coefficients of the displacement and the rotational speed of pump, this method can meet the different requirements on dynamic response and energy loss of system.

**WI.14 P0884**
**Subspace Identification and Model Predictive Control for Buildings**
*Jiri CIGLER, Samuel PRIVARA*  
Czech Technical University in Prague

Model predictive controller presented in this article makes use of both weather forecast and thermal model of a building to control inside temperature. This, by sharp contrast to conventional control strategies such as weather-compensated heating control (heating-curve controller), enables utilization of thermal capacity of the building, thus minimization of energy consumption. The inside temperature can be maintained at desired levels independent of the outside weather conditions using modified formulation of predictive controller. Nevertheless, proper identification of the building model is crucial. The models of multiple-input multiple-output systems can be identified using subspace methods. The controller was tested on (and applied to) the real building and results were compared with a present heating control.

**WI.15 P0960**
**Modeling Method based on Signal Flow Graph Correlation Matrix and its Application**
*Bingxin HAN, Lixian LIU, Zhanfeng GAO, Liqiang DU*  
Shijiazhuang Tiedao University

This paper presents a new modeling method based on signal flow graph correlation matrix. Firstly, according to the signal flow graph, a signal tree can be selected. Based on the signal tree, a signal branch and the node can be added, finding independent loop - loop incidence matrix. The correlation matrix can determine the relevance of the loop, and help seek its loop gain. Moreover, mathematical model can be figured out by using Mason formula. Theoretical analysis and experimental results show that when the nodes increase, this method is simpler and the meaning of the formula is clearer. In comparison to existing methods, our method has obvious advantages in calculation and expression. Our method makes the model of the system more accurate, and the modeling process becomes faster and more convenient.

**WI.16 P1080**
**Laboratory Demonstration for Model Predictive Multivariable Control with a Coupled Drive System**
*Steven Weidong SU, Hung T NGUYEN, Quang P HA*  
University of Technology, Sydney

Teaching multivariable control usually involves a certain level of mathematical sophistication and hence requires some labaratorial exemplification of the material given in formal lectures. This paper reports on a hands-on approach to multivariable control education via the implementation of a model predictive controller on a two-input, two output coupled drive apparatus. This scaled-down system represents many industrial processes while provides an excellent set-up for demonstrating the cross-coupled effects in multi-input multi-output systems. Here, a model predictive controller (MPC) is developed and implemented on the basis of a constrained optimization problem to show control performance via the belt tension and velocity outputs, demonstrate the decoupling capability, and also illustrate such issues as control input saturation, the selection of operating point, reference inputs, and system robustness to external disturbance and varying parameters. The implementation is based on Labview and MATLAB Model Predictive Control Toolbox.

**WI.17 P0696**
**Stability Analysis of Practical Anisotropic Swarms**
*Liangshun WANG, Huajing FANG*  
Huazhong University of Science and Technology

This paper considers finite sense ability, finite motion ability and anisotropy into swarm system. We first construct an anisotropic model with a class of attraction and repulsions in terms of finite sense ability. Then we analyze their stability. It is shown that the individuals of the swarm model aggregate and eventually enter into a bounded region around the swarm center. This study is more applicable to practical engineering.
**WI.18 P0793**

**Instantaneous Availability Model with 2-D Discrete Characteristics of One-unit Repairable Systems**

Yi YANG, *Yongli YU, Lichao WANG, Rui KANG  
Beihang University  
*Ordnance Engineering College

The discrete-time one-unit repairable system was studied, whose lifetime, repair delay time, corrective maintenance time and preventive maintenance time are all assumed to be random variables with general discrete distributions. We investigated the relationship of system states including operational state, waiting state for repair, state for preventive maintenance, and state for corrective maintenance. Then the state transition model was built. Furthermore, we established the instantaneous availability model which has the 2-D discrete characteristics, and on the basis, we proposed the optimal maintenance interval model. Finally, numerical examples were given to illustrate the proposed models.

**WI.19 P0891**

**Design of Signal Control Structures using Formal Methods for Railway Interlocking Systems**

Oytun ERIS, Ilhan MUTLU  
Istanbul Technical University

Today the relay based train interlocking systems are changing into programmable software interlocking systems. Looking at the hardware aspect, safety certified components can be used in order to satisfy the safety requirements of train interlocking systems. But to satisfy the software requirements, the design and the programming of the interlocking system must be made by formal methods. Preparing function blocks for each kind of the field equipments can be a method in order to realize a railway interlocking system. The purpose of this paper is to develop a PLC program for the signal function blocks by using formal methods and make a comparison between them.

**WI.20 P0621**

**Haptic Microrobotic Intracellular Injection Assistance using Virtual Fixtures**

University of Canterbury  
*Deakin University

In manual cell injection the operator relies completely on visual information for task feedback and is subject to extended training times as well as poor success rates and repeatability. From this perspective, enhancing human-in-the-loop intracellular injection through haptic interaction offers significant benefits. This paper outlines two haptic virtual fixtures aiming to assist the human operator while performing cell injection. The first haptic virtual fixture is a parabolic force field designed to assist the operator in guiding the micropipette's tip to a desired penetration point on the cell's surface. The second is a planar virtual fixture which attempts to assist the operator from moving the micropipette's tip beyond the deposition target location inside the cell. Preliminary results demonstrate the operation of the haptically assisted microrobotic cell injection system.

**WI.21 P0526**

**Non-cooperative Target Assignment using Regret Matching**

Shemen KALAM, Mahbub GANI  
King's College London

In this paper, we have adopted a game theoretic approach to consider optimal assignment of targets to vehicles. We have taken optimality to mean that the cost of vehicle-target assignment is minimized where the cost is the sum of the Euclidean distances between a vehicle and its assigned target. This occurs when the set of targets is assigned to their nearest vehicles. In other words, each vehicle should assign themselves to a target located within the Voronoi region associated with the vehicle. Standard schemes require vehicle-vehicle communication at least to rank the targets according to the nearest neighbour rule. In our proposed model, there is no need for communication among the vehicles and only limited communication between the targets and the vehicles is required. Specifically, we have introduced an appropriate utility function which depends on the distance between the vehicles and targets and the number of vehicles engaging a particular target. The vehicles negotiate their choice of targets via regret matching. We present simulations which demonstrate that vehicles select targets that fall within their Voronoi region. For vehicles that do not have any targets within their Voronoi region, they select their nearest unassigned target. We also present analysis of how the designed utility function causes convergence of the vehicle-target assignment using regret matching.

**WI.22 P0567**

**3D Hydrodynamic Analysis of Biomimetic Robot Fish**

Zhenying GUAN, Weimin GAO, Nong GU, Saeid NAHAVANDI  
Deakin University

This paper presents a three-dimensional (3D) computational fluid dynamic simulation of a biomimetic robot fish. Fluent and user-defined function (UDF) is used to define the movement of the robot fish and the Dynamic Mesh is used to mimic the fish swimming in water. Hydrodynamic analysis is done in this paper too. The aim of this study is to get comparative data about hydrodynamic properties of those guidelines to improve the design, remote control and flexibility of the underwater robot fish.

**WI.23 P0577**

**6 Degrees of Freedom (DOF) Maritime Robotic**
Simulation Framework
Kuan Meng TAN, *Amir ANVAR, Tien-Fu LU
The University of Adelaide
*Defence Science and Technology Organisation
Testing and gauging Autonomous Underwater Vehicle (AUV) missions through observations and experimental trials prove to be time consuming and costly. A system capable of verifying the AUV control models prior to practical test is needed. One of the key aspects in the presented framework is AUV modeling which mainly covers the area of AUV dynamics. Based on this designed simulation framework, custom scenarios provided by the user can be modeled and its corresponding 6DOF dynamics can be observed. The simulation framework is built based on a developed AUV test-bed which was jointly upgraded by DSTO and the University of Adelaide.

WI.24 P0896
A Consistent Kinematic Modeling Method for Mobile Manipulators
Joono CHEONG
Korea University
In this paper, a consistent kinematic modeling method for mobile manipulators is proposed. We transform the mobile manipulators into conventional manipulators via appropriate change of kinematic structure. Consequently, analyses of kinematics for mobile manipulators can be conveniently carried out with the transformed manipulators. Cases of differential-drive and car-like types of mobile platforms are formulated, but theoretically not limited to these.

WI.25 P0532
Dynamic Analysis of a Flexure-based Mechanism for Precision Machining Operation
Yanling TIAN, Dawei ZHANG, *Bijan SHIRINZADEH
Tianjin University
*Monash University, Clayton
This paper presents the dynamic modelling and performance evaluation methodologies of a flexure-based mechanism for ultra-precision grinding operations. The mechanical design of the mechanism is briefly described. A piezoelectric actuator is used to drive the moving platform. A flexure-based structure is utilized to guide the moving platform and to provide preload for the piezoelectric actuator. By simplifying the Hertzian contact as a linear spring and damping component, a bilinear dynamic model is developed to investigate the dynamic characteristics of the flexure-based mechanism. Based on the established model, the separation phenomenon of the moving platform from the piezoelectric actuator is analyzed. The influence of the control voltage on the maximum overshoot is also investigated. The slope and cycloidal command signals are used to reduce and/or avoid the overshoot of such flexure-based mechanism under step command signal actuation condition. The effects of the rising time of the command signals on the maximum overshoot and the settling time are studied.

WI.26 P0748
Parallel Implementation of 3D Object Reconstruction in a Robotic Navigational Environment
Vijay S RAJPURHOT, *Manohara PAI M M
Gogte Institute of Technology Belgaum
*Manipal Institute of Technology, Manipal
Stereo vision systems in a Robotic navigation environment determine the depth in the form of a depth map image from two or more images which are taken at the same time, but from slightly different viewpoints. Ground suppression from depth map is essential for object reconstruction in 3D environment as the ground surface is considered as traveling medium than as an object. Ground separated depth map needs to be segmented to identify the objects of interest. Objects identified below the threshold size need to be removed from the scene. In this paper we propose a Fuzzy-based parallel object clustering algorithm to reconstruct the objects of interest in 3D environment from the ground suppressed depth map. The depth map is divided into Fuzzy layers in X-Z plane and these Fuzzy layers are processed in parallel to reconstruct the objects of interest in 3D environment using region growing method on a cluster computing setup. Experimental results show that Fuzzy logic effectively handles the uncertainty in object reconstruction process. The parallel implementation of the algorithm drastically reduces the time required for object reconstruction process in congested navigational environments.

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optimization theory. As a result, the optimized driving parameters for the mixed thrusters are achieved to bring the maximal propulsion while consuming the minimal energy. Experiments carried out in the pool prove the validity and rationality of the optimization results.

**WI.28 P0692**  
Random Force based Algorithm for Local Minima Escape of Potential Field Method  
Jinseok LEE, Yunyoung NAM, Sangjin HONG  
Stony Brook University

We address a new inherent limitation of potential field methods, which is symmetrically aligned robot-obstacle-goal (SAROG). The SAROG involves one critical risk of local minima trap. For dealing with the problem, we investigate the way how the local minima trap is recognized, and present our random force algorithm. The force algorithm has two categories of random unit total force (RUTF) and random unit total force with repulsion removal (RUTF-RR) which are selected based on the conditions of a robot, an obstacle and a goal.

**WI.29 P0784**  
Development of Human-friendly Robot Arm with Adjustable Joint Compliance  
Shinya KAJIKAWA, Masashi NASUNO, Kazuto HAYASAKA  
Tohoku Gakuin University

Safety is primary considered in designing a robot that operates in human environment. This paper presents a human-friendly robot arm designed so as to realize a physical interaction with human safely. This arm has a 3-D.O.F (shoulder joint : 2-D.O.F, elbow joint : 1-D.O.F). To guarantee the safety of robot motion, elbow joint has a multi-directional passive compliance. In this joint, two kinds of air cushions (Cushion A and Cushion B) are placed between a motor-driven disk and an output link. The rotational motion of the motor is transmitted to the output link with the friction force between the surface of Cushion A and the motor-driven disk. In addition, Cushion A plays following two important roles: (1) Absorption of external forces by its elastic deformation and slippage on the motor-driven disk and (2) Sensing the directions and amplitude of external forces with the pressure change in it. On the other hand, Cushion B controls the degree of pressing Cushion A against the motor-driven disk by its expansion. The increment of pressing force of Cushion A results in the increment of joint stiffness, because the elastic deformation and slippage of Cushion A are prevented. This paper describes the structure of the robot arm and the detail mechanism and performance of the proposed joint module.

**WI.30 P1157**  
Analysis of Real-time Velocity Compensation for Outdoor Optical Mouse Sensor Odometry  
Robert ROSS, John DEVLIN  
La Trobe University

This paper investigates the linearity of optical flow odometry with respect to velocity when using refocused optical mouse sensors for outdoor robotic navigation. Optical mouse sensors are small, inexpensive and contactless devices which include a low resolution CMOS camera, DSP hardware and optical flow firmware to provide optical displacement measurements in two dimensions. We perform experiments using different velocities, sampling periods and with decoupled acceleration to develop a linear, real-time compensation algorithm providing velocity corrected displacement measurements.

**WI.31 P0394**  
IVFH* : Real-time Dynamic Obstacle Avoidance for Mobile Robots  
Jie DONG, Xueming MA, Kaixiang PENG  
University of Science and Technology Beijing

VFH* could not make optimal choice of direction in the narrow stability region. An improved method called IVFH* enlarges certain value (CV), raise more grids, add to relative threshold and introduce the concept of reactive deformation links to improve the original algorithm. IVFH* use Newtonian Physics and Hooker’s Law to update the position of the nodes and deform the links in response to the motion of the obstacles, for avoiding dynamic obstacles in dynamic environment.

**WI.32 P0405**  
Complex Event Processing for Object Tracking and Intrusion Detection in Wireless Sensor Networks  
Anna University, Chennai  
*Tata Consultancy Services

Complex Event Processing (CEP) has received wider acceptability due to its systematic and multilevel architecture driven concept approach. CEP is an emerging technology in the field of data processing and identifying patterns of interest from multiple streams of events. High levels of integrated self learning applications can be developed. CEP is used in development of applications which have to deal with voluminous streams of incoming data with the task of finding meaningful events or patterns of events, and respond to the events of interest in real time. In this paper a CEP based application for object detection tracking in a Wireless Sensor Network (WSN) environment is proposed. Also the detection of an intruder using semantic query processing is proposed. ESPER, an open source Complex Event Processing engine is used to develop the application.

**WI.33 P0151**  
Multi-1D Block Matching Algorithm Based Motion Estimation Processor using Mixed-Signal Approach
Shin-Yeu LIN, *Chong-Wei SU, **Jung-Shou HUANG  
Chang Gung University  
*National Chiao Tung University  
**Elan Microelectronics Corporation

In this paper, we propose a Mixed Signal Parallel Multi 1Dimensional Block Matching Algorithm (MSPM-1D-BMA) based motion estimation (ME) processor. In contrast to the typical 2Dimensional full search block matching algorithm (2DFSBMA), the MSPM-1D-BMA based ME processor will greatly reduce the number of data movements in between memories. We employ a voting algorithm in the proposed ME processor to improve the accuracy of motion vector (MV) estimation. We have demonstrated that the MV estimation accuracy achieved by the proposed ME processor is much better than the existing fast block matching algorithms and is close to 2DFSBMA. We also demonstrated that the speed of the proposed ME processor approaches two times as that of the mixed signal 2DFSBMA based ME processor.

**WI.34** P0266  
Vehicle Combustion Quality Monitoring: A Scene Visibility-level Based Non-invasive Approach  
Masood Mehmood KHAN  
Curtin University

Pollutants interfere with light, restrict its reflection and so impair visibility. Scene visibility level is therefore used as a measure of air quality and pollution. Treating emission efflux as “some additional noise causing visibility impairment,” this work examines if the extracted visibility index from a thermal infrared (TIR) image can help in qualitative assessment of combustion efficiency. The thin-film regime like two dimensional TIR images of unleaded-petroleum run vehicles’ exhaust-plumes were first accommodated for time and space related compositional effects. The estimated ratios of visibility indices obtained from two sequential TIR images of the same exhaust plume were compared with their respective electrochemically sensed levels of oxides of nitrogen and combustibles. Initial results suggest that visibility indices extracted from TIR images of emission efflux would help in distinguishing low from high levels of emissions. TIR images can therefore assist in qualitative assessment of engine combustion efficiency.

**WI.35** P0872  
Primitive-based 3D Structure Inference from a Single 2D Image for Insect Modeling: Towards an Electronic Field Guide for Insect Identification  
Xiaozheng ZHANG, *Yongsheng GAO, Terry CAELLI  
National ICT Australia  
*Griffith University

3D insect models are useful to overcome viewing angle variations and self-occlusions in computer-assisted insect taxonomy for electronic field guides. The acquisition of 3D information is, however, unreliable due to the flexibility and small size of the insect bodies. This paper explores how to infer 3D insect models from a single 2D insect image, which will assist both insect description and identification. The 3D structure of the insect body is modeled from two geometric primitives, generalized cylinders and deformable ellipsoids. The primitives are fitted and warped based on both edge and medial axis constraints of the 2D image. Individualized 3D models are then built to approximate the insect structure. The proposed approach results in seemingly useful 3D insect models capable of representing the major morphological characteristics for a variety of insects with different body types. This method could be a helpful assistance for computer-assisted insect taxonomy and insect identification by entomologists and the public.

**WI.36** P0179  
An Approach for Raising the Accuracy of One-class Classifiers  
Chi-Kai WANG, Yung TING, Yi-Hung LIU  
Chung Yuan Christian University

The support vector data description (SVDD) is a method proposed to solve the problem of one-class classification. It models a hypersphere around the target set, and by the introduction of kernel functions, more flexible descriptions are obtained. In SVDD, the width parameter and the penalty parameter have to be given beforehand by the user. To automatically optimize the values for these parameters, the error on both the target and outlier data has to be estimated. Because no outlier examples are available, we propose a max-min range method for generating artificial outliers in this paper. By generating artificial outliers around the target set, the accuracy of classifiers will improve. At the last, we use four benchmark data sets: Iris, Wine, Balance-scale, and Ionosphere data base to validate the approach in this research indeed has better classification result.

**WI.37** P0372  
An Affine Invariant Interest Point and Region Detector based on Gabor Filters  
Wanying XU, Xinsheng HUANG, Xingwei LI, Ying ZHANG, Jie ZHANG, Wei ZHANG  
National University of Defense Technology

This paper presents a novel approach for interest point and region detection which is invariant to affine transformations. Such transformations introduce significant changes in the point location as well as in the scale and the shape of the neighborhood of an interest point. Our approach allows to solve for these problems simultaneously. The approach is based on three key ideas: 1) Interest points can be extracted based on local maxima of the normalized local energy maps. 2) Local extrema over scale of the normalized energy function indicate the presence of characteristic local structures. 3) The maximum response along all the orientations indicates the principle orientation of the local structure. We first extract interest points at multi-scales from the local energy map constructed by Gabor filter responses, and then select points at which a local measure is
maximal over scales. This allows a selection of distinctive points for which the characteristic scale is known. We then estimate the principle orientation through the orientational responses of Gabor filters and extend the detector to affine invariance by estimating the affine shape of a point neighborhood. The characteristic scale and the affine shape of neighborhood determine an affine invariant region for each point. Experimental results with synthetic images and natural images show the affine invariance performance of our approach. Comparative evaluation using the repeatability criteria demonstrates the comparable performance in the presence of large viewpoint changes.

WI.38 P0399
An Efficient Illumination Normalization Method in a Transformed Domain
Zhichao LIAN, Meng Joo ER
Nanyang Technological University
This paper proposes a novel illumination normalization approach with low computation complexity for face recognition. In this proposed method, a block-wise Walsh-Hadamard transform (WHT) is employed in the logarithm domain. An appropriate number of low-frequency WHT coefficients are zeroed to compensate for illumination variations. Experiments on different databases demonstrate that the proposed method obtains results comparable to those of conventional Discrete Cosine Transform method but with a higher efficiency. It also achieves better performances for cases with larger illumination variations. Furthermore, both analytical proof and experimental results demonstrate that principal component analysis (PCA) can be directly implemented in the WHT domain.

WI.39 P0638
A Comparative Study of Age-Invariant Face Recognition with Different Feature Representations
Meng CUI, Jiwen LU, Yap-Peng TAN
Nanyang Technological University
Age invariant face recognition is an important yet less investigated problem in the face recognition community. In this paper, we empirically evaluate state-of-the-art facial feature representations for age-invariant face recognition. Three representative features including local binary pattern (LBP), Gabor wavelets and gradient orientation pyramid (GOP) were applied, followed by a principal component analysis (PCA) to reduce the dimensions of the extracted features. Experimental results on the MORPH database, one of the largest publicly available face dataset containing thousands of longitudinal images are presented. Experimental results show that Gabor wavelets feature with five scales and eight orientations is the optimal feature representation method for age-invariant face recognition.

WI.40 P0907
A Weighted Voting Scheme for Recognition of

Faces with Illumination Variation
Amirhosein NABATCHIAN, Esam ABDEL-RAHEEM, Majid AHMADI
University of Windsor
A new method for face recognition based on weighted votes on different sub-images of a picture is proposed. The proposed method is robust under illumination variations and achieves the illumination invariants based on the reflectance-illumination model. The proposed method does not require any prior information about the face shape or illumination and can be applied on each image separately. It does not need multiple images in training stage to get the illumination invariants and is computationally efficient. Support vector machines are used as classifier. Several experiments are performed on Yale B and CMU-PIE databases. The system achieved 99.82% recognition rate in the Yale B and 99.74% for the CMU-PIE database.

WI.41 P1063
Combined Local and Holistic Facial Features for Age-Determination
Khoa LUU, Tien Dai BUI, Ching Y. SUEN, *Karl RICANEX
Concordia University
*University of North Carolina Wilmington
This paper presents an advanced age-determination technique that combines holistic and local features derived from an image of the face. A 30×1 Active Appearance Model (AAM) linear encoding of each face is produced to work as holistic features. Meanwhile, local features are extracted by using Local Ternary Patterns (LTP). These combined features are used to classify faces into one of two age groups (age-classification). An age-determination function is then constructed for each age group in accordance with physiological growth periods for humans - pre-adult (youth) and adult. Compared to published results, this method yields the highest accuracy rates in overall mean absolute error (MAE), mean absolute error per decade of life (MAE/D), and cumulative match score.

WI.42 P0667
Low Level Data Fusion of Laser and Monocular Color Camera using Occupancy Grid Framework
Qadeer BAIG, Olivier AYCARD
University of Grenoble 1
In this paper we have developed a technique for low level data fusion between laser and monocular color camera using occupancy grid framework in the context of internal representation of external environment for object detection. Based on a small variant of background subtraction technique we construct an occupancy grid for camera and fuse it with the one constructed for laser to get a combined view. The results obtained using Cycab simulator prepared by INRIA show the effectiveness of our technique.
Session TA1
Date : Thursday, 09 December 2010
Time : 1000 - 1200
Venue : Ball Room

Robust Control I
Chairs : Pierre APKARIAN
ONERA
Hisaya FUJIOKA
Kyoto University

TA1.1 P0989 1000 - 1020
Extended Blending Techniques with Applications in Robust Tracking Control and Fault-tolerant Control
Jun XU, *Lihua XIE, Kai Yew LUM
National University of Singapore
*Nanyang Technological University

In this paper, we extend the blending technique introduced by Blanchini et. al. to a general case. Different from the existing technique, where all the columns of the distribution matrices of the exogenous inputs should be linearly independent of each other, we only require that part of the columns are linearly independent, and the other matrices have full column ranks. Based on this blending technique, we present a novel approach to the robust fault-tolerant control scheme and robust tracking problem. The novelty lies in the fact that we can separately design the controller gains for different performance indices, while simultaneously achieving all the indices via an elegant construction of an overall controller. The design procedure is based on LMI techniques and basic linear algebra tools.

TA1.2 P0225 1020 - 1040
Nonsmooth μ Synthesis
Pierre APKARIAN, *Hoang Duong TUAN
ONERA
*The University of New South Wales

We revisit robust complex- and mixed-mu synthesis problems based on upper bounds and show that they can be recast as specially structured controller design programs. The proposed reformulations suggest a streamlined handling of μ synthesis problems using recently developed (local) nonsmooth optimization methods where both scalings or multipliers and a controller of given structure are obtained simultaneously. A first cut of the nonsmooth code for structured H-infinity synthesis is made available through the MATLAB R2010b Prerelease, Robust Control Toolbox Version 3.5 developed by The MathWorks, Inc.

TA1.3 P0603 1040 - 1100
Characterizing Approximated Differentiators in Digital Control
Hisaya FUJIOKA

Kyoto University

Characterizations of the approximated differentiator used in digital control are derived. The gap between the pure differentiator and its approximation is modeled as an additive perturbation. Two types of quadratic characterizations are obtained. One is the L2 gain and the other is related to the passivity property. The results guarantee that the perturbation is small when the sampling period is small enough, and can be used for robust control design when the perturbation is not negligible.

TA1.4 P0370 1100 - 1120
Mixed Nonlinear-Sliding Mode Control of an Unmanned Farm Tractor in the Presence of Sliding
Saint Petersburg University
*The University of New South Wales

The paper considers the problem of automatic path tracking by autonomous farming vehicles subject to wheel slips, which are characteristic for agricultural applications. Two guidance laws are proposed to solve this problem, and both explicitly take into account the constraints on the steering angle and ensure tracking an arbitrarily curved path. The first law is implemented by the pure sliding-mode controller, whereas the second one combines the sliding mode approach with a smooth nonlinear control law, using control chattering at the reduced amplitude as compared with the first law. Mathematically rigorous proofs of global convergence and robust stability of the proposed guidance laws are presented. In doing so, the slipping effects are treated as bounded uncertainties. Simulation results confirm the applicability and performance of the proposed guidance approach.

TA1.5 P0323 1120 - 1140
An Integral SMC Based Approach to Time-delay System Tracking
Gang LIU, *Alan ZINOBER, **Yuri SHTESSEL
Xi'an Jiaotong-Liverpool University
*The University of Sheffield
**University of Alabama in Huntsville

Output tracking in SISO fully linearizable nonlinear systems with a time delay is considered using integral sliding mode control based technique. Using Padé approximations for the delay, the actual delayed output is replaced by its approximation, by which the problem is reduced to the tracking of a nonminimum phase control system. This system is transformed into a corresponding state tracking problem, where the state tracking profiles are generated by the equations of the stable system centre. The integral sliding mode control approach is developed and good output tracking results are obtained. Smith Predictor is used to compensate the difference between the actual delayed output and its approximation and sliding mode observer/first order exact sliding mode
differentiator is used to deal with the perturbed system. A one-link robot arm example is used to show the effectiveness of this proposed method.

**Session TA2**

**Navigation of an Unmanned Helicopter in Urban Environments**

Michael HOY, Andrey V SAVKIN, *Matt GARRATT
The University of New South Wales
*UNSW at the Australian Defence Force Academy

When employing autonomous vehicles, it is desirable to use controllers which can be rigorously shown to always ensure safety is maintained. In this manuscript we compare two approaches for the problem of navigation through environments containing obstacles. The first uses boundary following to maintain an avoidance distance to obstacles, and the second uses a MPC-type algorithm to plan short range trajectories around detected obstacles, while ensuring the vehicle can be brought to a halt within the sensor radius. The controllers are subjected to analysis for robustness, and simulations are carried out with both a simple second order linear model and a realistic helicopter model for verification. The controller that planned ahead was found to give significantly better trajectories.

**Conditioned Switching between Two-Degree-of-Freedom Controllers for Plants with Changing Dynamics**

Joseph J YAME, Hanping QIAO
University Henri Poincare

This paper presents a self-conditioned implementation of any two-degree-of-freedom (TDOF) controller which allows a conditioned transfer when switching between a controller acting in closed-loop and another controller in a bank of idle controllers waiting to take over the control loop. Here, the notion of conditioned transfer is used to mean that after switching, good tracking performance is ensured albeit a jump at plant input may occur. This notion of conditioned transfer is different from the notion of bumpless transfer which refers to the requirement that no bump occurs at the plant input when switching between different controllers. A main feature of our study is that the switching among controllers is driven by the changing dynamics of the plant and moreover the technique is model-free. This is in contrast with most works reported in the literature on bumpless switching, where switching occurs between controllers driving a plant with fixed dynamics.

**Estimation of Next Human Behavior and its Timing for Human Behavior Support**

Aichi Institute of Technology
*Nagoya University

We have proposed a modeling and recognition method of human behaviors in this research. In the proposed modeling method, we have assumed that a person changes his behavior according to the change of the situation around him, and this concept is expressed by If-Then-Rules, which are called behavior rules. In behavior rules, the change of the situation around a person is described by Hidden Markov Model (HMM) which models multi-dimensional time series sensing data. In this research, a support system for human driving behaviors has been assumed as an example of application of the proposed model. In order to realize the system which shows a driver his next behavior, we propose an
estimation method of the next human behavior and the timing of its execution. The usefulness of the proposed method is examined through experimental results of behavior recognition with the constructed system.

**TA2.3 P0428 1040 - 1100**

A Metamodel for Background Ozone Level using Radial Basis Function Neural Networks

Herman WAHID, *Quang P HA, **Hiem NQUYEN-DUC
University of Technology Sydney
*University of Technology, Sydney
**Climate Change and Water, NSW

In air quality modelling, determination of the background ozone level is essential as it highly affects the accuracy of the photochemical air quality model. It is known that the background ozone level, especially in urban areas, has been changing over the years. Unfortunately, the reasons of that alteration were not clear and the background ozone itself was not easily derived in practice. In this paper, a new background ozone model will be developed by using the ozone ambient quality data and the meteorological data at the several stations in the Sydney basin. To accomplish the modelling process, an adaptively-tuned radial basis function neural network metamodel is proposed and utilised in the simulation. Different input parameters are considered to evaluate their influence on the constructed background ozone model. The proposed model, subject to some statistical criteria, demonstrates its capability of estimating the background ozone level with a reasonably good accuracy.

**TA2.4 P0505 1100 - 1120**

Hardware-in-the-Loop Simulation of Automatic Steering Control: Outer-Loop and Inner–Loop Control Design

Poh Ping EM, Khishbullah HUDHA, Mohd Hanif Bin HARUN, *Hishamuddin JAMALUDDIN
Universiti Teknikal Malaysia Melaka
*Universiti Teknologi Malaysia

This paper presents a 9-degree of freedom (DOF) vehicle model combined with a closed loop driver model for the purpose of developing vehicle lateral control. The driver model was developed to control the steering angle and uses the lookup table path as a reference for the control input. The proposed outer-loop controller structure for the driver model is a combination of proportional gain control with a yaw effect adaptive fuzzy logic control. A stepper motor model, rack and pinion model, and kinematics model of the steering system are also briefly introduced as an inner-loop sub-system for stepper motor actuated steering (SMAS) system. The proposed inner-loop controller is a closed-loop positioning control for the stepper motor. The performance of the outer-loop and inner-loop controllers were evaluated using predefined trajectory for lanekeeping and double lane change (DLC) maneuvers at 80 km/h constant speed. Both of the controller’s software-in-the-loop simulations (SILS) results were validated using an instrumented automatic steering test rig through the hardware-in-the-loop simulation (HILS). The SILS and HILS results show that the proposed driver model is capable of improving the Y-axis trajectory error and maneuvers significantly and the proposed SMAS system is capable of tracking the desired steering angle position and producing the front wheel steer angle for the use of vehicle model.

**TA2.5 P0978 1120 - 1140**

Automatic Synthesis of Reactive Agents

Insu SONG, *Guido GOVERNATORI, Joachim DIEDERICH
James Cook University Australia, Singapore campus
*National ICT Australia

This paper introduces a new approach to designing smart control chips that enables automatic synthesis of real-time control systems from agent specifications. An agent specification is compiled into a hardware description format, such as RTL-VHDL (Register Transfer Level--VLSI Hardware Description Language) or RTL Verilog, which is synthesized using computer-assisted tools to develop ASIC masks or FPGA configurations. A rule-based specification language called Layered Argumentation System (LAS) is defined and a sound and complete mapping to Verilog is developed. LAS combines fuzzy reasoning and non-monotonic reasoning. This enables chip designers to capture commonsense knowledge and concepts having varying degrees of confidence collaboratively and incrementally.

**TA2.6 P1054 1140 - 1200**

Generating Scenarios for a Mobile Robot with an Arm - Case Study: Assistance for Handicapped Persons

Philippe MORIGNOT, Mariette SOURY, Christophe LEROUX, Helena VOROBIEVA, Patrick HEDE CEA

In this paper, we present a mobile robot with an arm and a gripper, which can generate its own scenarios before executing them. Hand-written scenarios, as we previously did, are not applicable any longer, since a wider range of scenarios is aimed at, which cannot be predicted in advance. Our approach involves task planning, for scenario generation, and finite state automation, for scenario execution. Our robot is used for servicing handicapped or ageing persons in their apartment.
**Session TA3**

**Date:** Thursday, 09 December 2010  
**Time:** 1000 - 1200  
**Venue:** Kingfisher  

**Localization, Navigation and Mapping II**  

**Chairs:**  
K SRIDHARAN  
Indian Institute of Technology, Madras  
Jack Jianguo WANG  
University of Technology, Sydney  

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**TA3.1 P0342 1000 - 1020**  
**Maintaining Visibility of a Moving Target: Maximizing Escape Time vs. Exposure Time**  
Ibrahim AL-BLUWI, *Ashraf ELNAGAR  
Univertiste de Toulouse  
*University of Sharjah  

This paper presents a novel approach for the problem of tracking a moving target in a global dynamic environment. The robot has to move such that it keeps the target visible for the longest time possible, and at the same time, avoid colliding with any of the moving obstacles. This paper presents a solution that is based on the idea of three interacting components which perform: tracking, collision avoidance and motion selection. The proposed solution is validated using a comprehensive set of simulations, which show that transition from tracking in static environments to tracking in dynamic environments can be done without much loss in robot safety or tracking ability.

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**TA3.2 P0402 1020 - 1040**  
**An Omnidirectional Time-of-Flight Camera and its Application to Indoor SLAM**  
Katrin PIRKER, Matthias RÜTHER, Horst BISCHOF, *Gerald SCHWEIGHOFER, *Heinz MAYER  
Graz University of Technology  
*Joanneum Research GmbH  

Photonic mixer devices (PMDs) are able to create reliable depth maps of indoor environments. Yet, their application in mobile robotics, especially in simultaneous localisation and mapping (SLAM) applications, is hampered by the limited field of view. Enhancing the field of view by optical devices is not trivial, because the active light source and the sensor rays need to be redirected in a defined manner. In this work we propose an omnidirectional PMD sensor which is well suited for indoor SLAM and easy to calibrate. Using a single sensor and multiple planar mirrors, we are able to reliably navigate in indoor environments to create geometrically consistent maps, even on optically difficult surfaces.

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**TA3.3 P0406 1040 - 1100**  
**Ground-Plane Classification for Robot Navigation - Combining Multiple Cues Toward a Visual-Based Learning System**  

*Joanneum Research GmbH  

This paper describes a vision-based ground-plane classification system for autonomous indoor mobile-robot that takes advantage of the synergy in combining together multiple visual cues. A priori knowledge of the environment is important in many biological systems, in parallel with their reactive systems. As such, a learning model approach is taken here for the classification of the ground/object space, initialised through a new Distributed-Fusion (D-Fusion) method that captures colour and textural data using Superpixels. A Markov Random Field (MRF) network is then used to classify, regularise, employ a priori constraints, and merge additional ground/object information provided by other visual cues (such as motion) to improve classification images. The developed system can classify indoor test-set ground-plane surfaces with an average true-positive rate of 90.92% to 7.78% respectively on test-set data. The system has been designed in mind to fuse a variety of different visual cues. Consequently it can be customised to fit different situations and/or sensory architectures accordingly.

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**TA3.4 P0677 1100 - 1120**  
**Mapping Large Scale Environments by Combining Particle Filter and Information Filter**  
Mahesh MOHAN, K. Madhava KRISHNA  
International Institute of Information Technology, Hyderabad  

This paper presents two approaches to combine two popular mapping strategies, namely Particle Filters and the Information Filters. The first method describes how the Particle Filter can be incorporated into the Information Filter framework, by building local submaps using the Particle Filter and combining them using an Information Filter to obtain a global map. Using the Particle Filter locally reduces the linearization errors and is useful in handling ambiguous data associations, while the Information Filter keeps track of uncertainty over long periods of time, thereby avoiding FastSLAM's tendency to become overconfident. The second method shows how the Information Filter can be used in the Particle Filter framework as a simple means of remembering the filter's uncertainty. This can then used to re-populate particles while closing loops. This not only handles nonlinearities, but is also more robust for loop closing because, unlike the Particle Filter, the Information Filter does not exhibit forgetfulness of a trajectory's past.

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**TA3.5 P1010 1120 - 1140**  
**Map-aided 6-DOF Relative Pose Estimation for Monocular SLAM using Sparse Information Filters**  
Zhan WANG, Gamini DISSANAYAKE  
University of Technology, Sydney  

This paper addresses the problem of mapping
three-dimensional environments from a sequence of images taken by a calibrated camera, and simultaneously generating the camera motion trajectory. This is the Monocular SLAM problem in robotics, and is akin to the Structure from Motion (SFM) problem in computer vision. We present a novel map-aided 6-DOF relative pose estimation method based on a new formulation of the Monocular SLAM that is able to provide better initial estimates of new camera poses than the simple triangulation traditionally used in this context. The ‘6-DOF’ means relative to the map which itself is up to an unobservable scale. The proposed pose estimator also allows more effective outlier rejection in matching features present in the map and features extracted from two consecutive images. Our Monocular SLAM algorithm is able to deal with arbitrary camera motion, making the smooth motion assumption, which is required by the typically used constant velocity model, unnecessary. In the new Monocular SLAM formulation, the measurements of extracted features from images are partitioned into those used for the estimation of the environment and those used for estimating the camera motion. The new formulation enables the current map estimate to aid achieving the full 6-DOF relative pose estimation up to the mapping scale while maximally exploiting the geometry information in images. Experiment results are provided to verify the proposed algorithm.

**TA3.6 P1103 1140 - 1200**

Robotic Mapping with Simple Sensing and Processing Hardware - Algorithm and Architecture

Leena VACHHANI, *K SRIKHDARAN
Indian Institute of Technology, Bombay
*Indian Institute of Technology, Madras

This paper considers the problem of generating a map of an indoor environment by a mobile robot when constraints are placed on sensing and processing hardware. In particular, we present an algorithm for Voronoi diagram generation by a mobile robot equipped merely with inexpensive ultrasonic sensors and a low-end Field Programmable Gate Array (FPGA) device. The algorithm is based on the definition of the Voronoi diagram in terms of the perpendicular-bisector. Deviations from the Voronoi diagram of the (reference) point on the robot are corrected by a novel algorithm that is devoid of division and floating-point operations. An efficient architecture and experiments with an FPGA-based robot are also presented.

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**Session TA4**

Date: Thursday, 09 December 2010
Time: 1000 - 1200
Venue: Nightingale

**Instrumentation Systems**

Chairs: Changyun WEN
Nanyang Technological University

**TA4.1 P0871 1000 - 1020**

A New Methodology of Continuous and Noninvasive Blood Pressure Measurement by Pulse Wave Velocity

Yan CHEN, Changyun WEN, *Guocai TAO, *Min BI
Nanyang Technological University
*Southwest Hospital

Blood pressure (BP) is one of the most important physiological parameters reflecting cardiovascular status of people. Continuous and non-invasive BP measurement, which can provide beat-to-beat BP information and call attention to the doctor if the patent is in danger during surgery, plays a very important role in safety control in operation and intensive care. In this paper, a novel and complete methodology of continuous and non-invasive BP measurement by PWV without calibration by other methods such as cuff sphygmomanometer is proposed. Critical parts of this study include modeling BP-PWV relationship and identifying two PWVs relative to systolic blood pressure (SBP) and diastolic blood pressure (DBP) respectively. Some benchmark models for 20-year-old and 60-year-old age groups are developed and applied to BP measurement in clinical trials. The clinically obtained results meet the test standard in ANSI/AAMI SP10, which attests the feasibility of the measuring method. Lastly, the continuous SBP and DBP measurement results by PWV method are shown.

**TA4.2 P1049 1020 - 1040**

Mechanoinduction of Reduction in the Stiffness of Zebrafish Chorion

Joo Hoo NAM, Peter C Y CHEN, *Zhe LU, **Hong LUO, Ruowen GE, **Wei LIN
National University of Singapore
*University of Toronto
**Singapore Institute of Manufacturing Technology

In this paper, we report our investigation on the force-induced responses of zebrafish chorion before and after being perturbed by an externally applied prescribed force. Our experimental results show that application of an external force leads to a reduction in the stiffness of the zebrafish chorion, and that variation in such a reduction is strongly influenced by the perturbation time. Our results provide evidence supporting the hypothesis that the stiffness of some cellular organism may be modified by the controlled application of an appropriate mechanical force, and demonstrate the potential of force-feedback control in micro/nano-manipulation as a promising
approaches include engineering technique for studying disease properties and manipulating cellular biological functions.

**TA4.3 P0409 1040 - 1100**

**Approximate Entropy-based Leak Detection using Artificial Neural Network in Water Distribution Pipelines**

*Jin YANG, Yumel WEN, Ping LI*
Chongqing University

Correlation techniques are widely used to locate leaks in buried water pipes. However, a distinct peak in the cross-correlation of two spatially separately collected acoustic signals may result from a non-leak acoustic source outside the pipe. And the peak not related to a real leak will result in a false leak location. So it is necessary to determine whether or not a real leak exists beforehand. In this paper, a new leak detection method using approximate entropy is proposed to discriminate the leak acoustic signals from the non-leak signals. In this method, the autocorrelation function values for the delay larger than the correlation length of the signal, not the signal itself or its entire autocorrelation function values, are used to extract or evaluate the self-similarity degree of the signal by the approximate entropy. A neural-network approach has been developed as a classifier, which uses the identified self-similarity degrees as the network inputs. The proposed leak detection method has been employed to identify the leak in the buried water pipelines, and achieved a 92.5% correct detection rate.

**TA4.4 P0596 1100 - 1120**

**Service Provider Architecture for Dynamically Reconfigurable Virtual Instruments in Networked Environments**

*Sundaramurthy RAMALINGAM, Dananjayan PERUMAL*
Pondicherry Engineering College

This paper proposes an online service provider architecture for reconfigurable, expandable and coherent virtual instruments. Using an FPGA chip with embedded software-core processor which provides both software-programmable and hardware-reconfigurable abilities, it is possible for us to construct a hardware kernel that can serve as the kernel of versatile measurement instruments. Reprogramming the embedded processors and reconfiguring the internal FPGA logic in the hardware kernel, we can implement various instrumental functions. The possibility of modifying the measurement procedure simply by changing the algorithm executed, which imitates hardware kernel for measurement instruments, by the computer-based architecture/software-core processor without replacing the hardware components makes the experimental activity easier. But the existing reconfigurable virtual instrument setups make the user to reinvent the wheel and make measurement process a tedious one. In this paper a novel service provider architecture is proposed which allows the user to dynamically reconfigure the hardware depending upon their measurement needs. With adaptively reconfiguring the hardware kernel, SDI concept can easily respond to the rapidly changing user-application-specified needs in measurement and test markets in a distributed measurement system (DMS).

**TA4.5 P0700 1120 - 1140**

**Unsteady Flow Rate Generating System for Gas using Isothermal Tank based on Disturbance Observer**

*Xiaoxin WANG, Tao WANG, Guangzheng PENG,*
*Yanbing TIAN*
Beijing Institute of Technology

*A Generating system of unsteady flow rate for gas using an isothermal tank is proposed. With the servo valves installed at upstream and downstream of the isothermal tank, the unsteady flow can be completely controlled. Moreover, by analyzing the characteristics of the servo valve, a feed forward compensator is designed to improve the response of the system. A fuzzy-PID controller is introduced for the high nonlinearity of compressible fluids control system. Differential operation is involved in the control process, which may amplify the noise greatly. Hence a disturbance observer is employed to reduce the noise to a permissible range. The experiment shows that the frequency of the unsteady flow rate obtained from the generating system is up to 10 Hz.*

**TA4.6 P0754 1140 - 1200**

**Prototype Development of Hybrid Temperature Recorder Monitoring System**

*Olarn WONGWIRAT, Keelati OONCHOM, Benjaporn ARNUTTINANON*
King Mongkut's Institute of Technology Ladkrabang

Currently, the calibration of burn-in chambers used in a HDDs (Hard Disk Drives) production line requires an engineer to manually monitor temperatures at the hybrid temperature recorders throughout the entire period of calibration process. It is a time consuming operation and considered an inefficient process, due to a large number of burn-in chambers used in the production line comparing with a limited number of engineers to operate. Therefore, this paper describes the prototype development of hybrid temperature recorder monitoring system implemented to improve the current calibration process of burn-in chamber. The work in this paper applies an object-oriented analysis and design methodology (OOADM) in the development process. The proposed system comprises two subsystems, i.e., a temperature recording subsystem and a monitoring subsystem, interconnected through a wireless network. The temperature recording subsystem performs capturing temperatures from sensors inside the burn-in chamber and sending the temperature data to a central server at the monitoring subsystem in the engineering office for monitoring in real-time. When the errors occur during the calibration process, the alarm signal is displayed and sent to the engineer for alerting. Furthermore, the temperature data is stored in a database for future verification and reference.
Session TA5 - Invited Session

Date: Thursday, 09 December 2010
Time: 1000 - 1140
Venue: Pelican

Collaborative UAV and UGV Systems

Chairs: Patrick DOHERTY
Linköping University

TA5.1 P1151 1000 - 1020
Cooperative Ground Target Tracking with Input Constraints

Senqiang ZHU, Danwei WANG
Nanyang Technological University

This paper considers the problem of cooperative target tracking with multiple unmanned aerial vehicles (UAVs) subject to input constraints. Cooperation of multiple UAVs to track a moving target can provide better performance and enhance the robustness. However, the physical constraints of the UAVs pose a significant challenge on the UAV controller design. In this paper, the relative course rate controller for a single UAV is firstly developed based on a guidance vector field. Cooperative control strategy of multiple UAVs is studied and a variable airspeed controller is proposed to regulate temporal separation of UAVs. Simulation results are provided to demonstrate the effectiveness of the proposed approach.

TA5.2 P1152 1020 - 1040
Formation Control of Multi-robot Systems

Shuai LIU, *Chun-Lin CHEN, Lihua XIE, *Yeong-Hwa CHANG
Nanyang Technological University
*Chang Gung University

In this paper, we consider formation control problem for multi-robot systems under an undirected communication network. All the robots will track a leader, while form a desired formation. The leader can be static or dynamic. A distributed formation controller with neighbors’ input information is applied. For practical implementation, control input information from neighbors can only be received after some time delays. It is therefore shown that the distributed control protocol using time delayed control input information from neighbors guarantees the formation of the multi-agent system for any nonnegative delay. We will implement the new protocol on the Amigo robots. The experimental results will demonstrate the effectiveness of the new protocol.

TA5.3 P1154 1040 - 1100
Federated DyKnow, a Distributed Information Fusion System for Collaborative UAVs

Fredrik HEINTZ, Patrick DOHERTY
Linköping University

As unmanned aerial vehicle (UAV) applications are becoming more complex and covering larger physical areas there is an increasing need for multiple UAVs to cooperatively solve problems. To produce more complete and accurate information about the environment we present the DyKnow Federation framework for distributed fusion among collaborative UAVs. A federation is created and maintained using a multi-agent delegation framework which allows high-level specification and reasoning about resource bounded cooperative problem solving. When the federation is set up, local information is transparently shared between the agents according to specification. The work is presented in the context of a multi UAV traffic monitoring scenario.

TA5.4 P1155 1100 - 1120
Generating UAV Communication Networks for Monitoring and Surveillance

Per-Magnus OLSSON, Jonas KVARNSTRÖM, Patrick DOHERTY, Oleg BURDAKOV, Kaj HOLMBERG
Linköping University

An important use of unmanned aerial vehicles is surveillance of distant targets, where sensor information must quickly be transmitted back to a base station. In many cases, high uninterrupted bandwidth requires line-of-sight between sender and transmitter to minimize quality degradation. Communication range is typically limited, especially when smaller UAVs are used. Both problems can be solved by creating relay chains for surveillance of a single target, and relay trees for simultaneous surveillance of multiple targets. In this paper, we show how such chains and trees can be calculated. For relay chains we create a set of chains offering different trade-offs between the number of UAVs in the chain and the chain’s cost. We also show new results on how relay trees can be quickly calculated and then incrementally improved if necessary. Encouraging empirical results for improvement of relay trees are presented.

TA5.5 P1156 1120 - 1140
Automated Planning for Collaborative UAV Systems

Jonas KVARNSTRÖM, Patrick DOHERTY
Linköping University

Mission planning for collaborative Unmanned Aircraft Systems (UAS:s) is a complex topic which involves trade-offs between the degree of centralization or decentralization required, the degree of abstraction in which plans are generated, and the degree to which such plans are distributed among participating UAS:s. In realistic environments such as those found in natural and man-made catastrophes where emergency services personnel are involved, a certain degree of centralization and abstraction is necessary in order for those in charge to understand and eventually sign off on potential plans. It is also quite often the case that unconstrained distribution of actions is inconsistent with the loosely coupled interactions and dependencies which arise between collaborating systems. In this article, we present a
new planning algorithm for collaborative UASs based on combining ideas from forward chaining planning with partial-order planning leading to a new hybrid partial-order forward-chaining (POFC) framework which meets the requirements on centralization, abstraction and distribution we find in realistic emergency services settings.

Session TA6
Date: Thursday, 09 December 2010
Time: 1000 - 1200
Venue: Oriole

Image/Video Analysis I
Chairs: Mani Maran RATNAM
Universiti Sains Malaysia
Yongqiang YE
Nanjing University of Aeronautics and Astronautics

TA6.1 P0254 1000 - 1020
Focus Measure in a Liquid-Filled Diaphragm (LFD) Lens using Passive Auto-focus Method
Soran Jalal ABDULLAH, Mani Maran RATNAM, Zahurin SAMAD
Universiti Sains Malaysia

Auto-focusing in imaging systems depends on the determination of the correct image focus criterion. In this research, the image captured by a liquid-filled diaphragm (LFD) fluid lens was analyzed to determine a focus measure criterion that can be used to establish the correct focus and thus quantify the image quality. The LFD lens was actuated using a stepper-motor driven syringe mechanism. The lens diaphragm was made of polydimethylsiloxane (PDMS) polymer that exhibit good optical properties. The lens focal length was controlled by varying the fluid volume within the diaphragm lens. A CCD camera was attached to the fluid lens to capture live images of a binary target. The edge slope width (ESW) of the pixel intensity profile across the white-to-black transition region in a binary target was used as the focus measure. The experiments carried out showed the viability of the proposed focus measure criterion for automatically focusing the image formed by a diaphragm-type fluid lens.

TA6.2 P0281 1020 - 1040
Online Background Learning for Illumination-robust Foreground Detection
Dawei LI, Lihong XU, *Erik GOODMAN
Tongji University
*Michigan State University

This paper presents a background modeling algorithm and a foreground detecting method which is robust against illumination change, providing a novel and practical choice for intelligent video surveillance systems using static cameras. This paper first introduces an online Expectation Maximization algorithm which is developed from the basic batch edition to update the mixture models in real time. Then a spherical K-means clustering method is used to provide more accurate direction for the update of Gaussian Mixture Models after a deep study of RGB space features under illumination changes. Foreground detection is carried out using a statistical framework and RGB pixel intensity judgments. The results show the proposed algorithm outcompete
several classic methods in efficiency, accuracy, and robustness to perturbations from illumination changes, on a sampling of problems.

**TA6.3 P0315 1040 - 1100**

An Automatic System for Multi-View Face Detection and Pose Estimation

Ying YING, Han WANG, *Jian XU
Nanyang Technological University
*Singapore Institute of Manufacturing Technology

Over the past few years, multi-view face detection issue has become one of the most attractive research topics in the field of computer vision. In this paper, a novel automatic system for multi-view face detection and pose estimation is proposed. Our approach adopts modified appearance-based learning methods to build corresponding face detectors and pose estimators, and detects multi-view faces according to a coarse-to-fine structure. The experiments not only demonstrate the ability of our system to automatically identify facial images with a high degree of accuracy, but also verify its ability to estimate the pose angles.

**TA6.4 P0346 1100 - 1120**

Nonuniformity Correction of Infrared Images based on Bivariate Quadratic Model

Xiubao SUI, Qian CHEN, Guohua GU, Ning LIU
Nanjing University of Science and Technology

The spatial fixed-pattern noise (FPN) compromises severely the quality of the acquired imagery, even makes such images inappropriate for some applications. In order to lower the FPN, some critical nonuniformity correction (NUC) algorithms such as NUC based on linear model, scene-based NUC and so on have been developed. But each algorithm has some drawbacks: restricted application in small dynamic range of objects temperature, low performance under the drift of the environment temperature and complex calculations. In these cases, we develop a bivariate and quadratic model of the FPA and the NUC technique based on the model. The proposed method does not need any assumptions and is a good solution for hardware implementation. It overcomes the drawbacks of the critical algorithm mentioned above. The last simulations and experiments show that the proposed algorithm exhibits a superior correction effect in both large objects temperature range and environment temperature range.

**TA6.5 P0587 1120 - 1140**

Preliminary Investigation of Thermal Hartmann Wavefront Sensing

Liping ZHAO, *Kelvin Jian Aun OOI, Xiang LI, *Lay Kee ANG
Singapore Institute of Manufacturing Technology
*Nanyang Technological University

We present a novel technique for thermal imaging in capitalisation on the Hartmann wavefront sensing technology for purposes of 3-D sensing. The issues of reflection induced noises, diffuse nature of thermal radiation, and directionality of emissivity, which might affect the results of thermal Hartmann wavefront sensing, are also discussed.

**TA6.6 P0976 1140 - 1200**

A Novel Fractional-order Signal Processing Based Edge Detection Method

Haibo YANG, Yongqiang YE, *Danwei WANG, Bin JIANG
Nanjing University of Aeronautics and Astronautics
*Nanyang Technological University

Image edge detection is a classic problem of machine vision and image processing. Edge detection often uses an integer-order differential operation. The paper adopts fractional differentiation and integration to obtain a new edge detection operator. The performances in terms of detection accuracy and noise immunity of the new operator are compared with those of the traditional operators through examples. The comparison shows that the new operator is promising.
Session TA7 - Invited Session

Date : Thursday, 09 December 2010
Time : 1000 - 1200
Venue : Bluebird

Computer Vision & Pattern Recognition

Chairs : Soodamani RAMALINGAM
         University of Hertfordshire

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TA7.1 P1107  1000 - 1020
License Plate Localisation based on Morphological Operations
Xiaojun ZHAI, Faycal BENSAALI, Soodamani RAMALINGAM
University of Hertfordshire

Automatic Number Plate Recognition (ANPR) systems allow users to track, identify and monitor moving vehicles by automatically extracting their number plates. This paper presents an improved method to locate car plates in an ANPR system. The proposed method is based on morphological open and close operations where different Structuring Elements (SE) are used to maximally eliminate non-plate region and enhance plate region. This method has been tested using a database of UK number plates and results achieved have shown significant improvements in terms of the detection rate compare to other existing plate localisation systems.

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TA7.2 P1109  1020 - 1040
Edge Detection Comparison for License Plate Detection
Zuwena MUSOROMY, Soodamani RAMALINGAM, *Nico BEKOOG
University of Hertfordshire

*CitySync Ltd.

The detection of license plate region is the most important part of a vehicle's license plate recognition process followed by plate segmentation and optical character recognition. Edge detection is commonly used in license plate detection as a preprocessing technique. This paper compares the performance of the image enhancement filters when used in edge detection algorithms combined with connected component analysis to extract license plate region.

The experimental comparison of Canny, Kirsch, Rothwell, Sobel, Laplace and SUSAN edge detectors on gray scale images shows that Canny yields high plate detection of 98.2% tested on 45,032 UK images containing license plates at 720X288 resolution captured under various illumination conditions. The average processing time of one image is 56.4 ms.

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TA7.3 P1113  1040 - 1100
Efficient Character Segmentation on Car License Plates
Lihong ZHENG, Junbin GAO, *Xiangjian HE
Charles Sturt University
*University of Technology, Sydney

In this paper an improved hill climbing algorithm based method is presented to cut character out of the license plate images. Although there are many existing commercial LPR systems, with poor illumination conditions and moving vehicle the accuracy impaired. After examination and comparison of two different types of image segmentation approaches, the hill climbing algorithm based method gave a better image segmentation results. The hill climbing algorithm was modified by introducing automatic parameter determination and smart searching. After modification it efficiently detects the peaks (local maxima) that represent different clusters in the global histogram of an image. The process is successful by getting a clean license plate image removing all unwanted areas. While testing by the OCR software, the experimental results show a high accuracy of image segmentation and significantly higher recognition rate after non-character areas are removed. The recognition rate increased from about 30.6% before our proposed process to about 91.3% after all unwanted non-character areas are removed. Hence, the overall recognition accuracy of LPR was improved.

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TA7.4 P0429  1100 - 1120
Human Detection using Local Shape and Non-Redundant Binary Patterns
Duc Thanh NGUYEN, Wangping LI, Philip OGUNBONA
University of Wollongong

Motivated by the advantages of using shape matching technique in detecting objects in various postures and viewpoints and the discriminative power of local patterns in object recognition, this paper proposes a human detection method combining both shape and appearance cues. In particular, local shapes of the body parts are detected using template matching. Based on body parts' shapes, local appearance features are extracted. We introduce a novel local binary pattern (LBP) descriptor, called Non-Redundant LBP (NRLBP), to encode local appearance of human. The proposed method was evaluated and compared with other state-of-the-art human detection methods on two commonly used datasets: MIT and INRIA pedestrian test sets. We also performed extensive experiments on selecting appropriate parameters as well as verifying the improvement of the proposed method through all stages of the framework.

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TA7.5 P0548  1120 - 1140
Graph Matching Based Hand Posture Recognition using Neuro-Biologically Inspired Features
Pramod Kumar PISHARADY, Prahlad VADAKKEPAT, Ai Poh LOH
National University of Singapore

An elastic graph matching algorithm using biologically inspired features is proposed for the recognition of hand postures. Each node in the graph is labeled using an image feature extracted using the computational model of the ventral stream of visual
cortex. The graph nodes are assigned to geometrically significant positions in the hand image, and the model graphs are created. Bunch graph method is used for modeling the variability in hand posture appearance. Recognition of a hand posture is done by the elastic graph matching between the model graphs and the input image. A radial basis function is used as the similarity function for the matching process. The proposed algorithm is tested on a 10 class hand posture database which consists of 478 grey scale images with light and dark backgrounds. The algorithm provided better recognition accuracy (96.35%) compared to the reported results (93.77%) in the literature.

**Face Recognition using Discrete Cosine Transform and Fisher Linear Discriminant**

*Vaidehi VIJAY KUMAR,* *Naresh Babu N. T, H AVINASH, M D VIMAL, A SUMITRA,* **Balmuralidhar P,** **Girish CHANDRA**

Anna University, Chennai
*Madras Institute of Technology, Chennai
**Tata Consultancy Services

In this paper, an efficient method for face recognition based on the Discrete Cosine Transform (DCT), Fisher Linear Discriminant (FLD) and classifier is presented. First, the dimensionality of the original face image is reduced using the DCT and illumination variations are alleviated by discarding the first few low-frequency DCT coefficients. FLD is applied to the selected DCT coefficients to discriminate the invariant facial features. The KNN classifier is used for the recognition of the faces using the features extracted from the FLD. Simulation results show that the proposed system achieves better performance with high training and high recognition rate as well as very good illumination robustness.
Session TM2
Date: Thursday, 09 December 2010
Time: 1310 - 1510
Venue: Canary

Feature Extraction, Grouping and Segmentation I

Chairs: Kezhi MAO
Nanyang Technological University
Andrzej SLUZEK
Nanyang Technological University

TM2.1 P0415 1310 - 1330
Detection and Segmentation of Near-duplicate Fragments in Random Images
Andrzej SLUZEK, *Mariusz PARADOWSKI, Duanduan YANG
Nanyang Technological University
*Wroclaw University of Technology

Retrieval of near-duplicate image fragments is one of the most challenging problems in CBIR (content-based image retrieval). The objective is to identify almost the same fragments in random images of unpredictable contents. Such fragments usually represent identical object, though captured from a different viewpoint, under different photometric conditions and/or by a different camera. The paper presents techniques developed for such applications. In general, the proposed methods are based on statistical properties of keypoint similarities between compared images. In the first approach, we assume that near-duplicates are (approximately) related by affine transformations, i.e. the underlying objects are locally planar. In the second approach, a wider range of shape distortions is acceptable. Implementations (including online detection in real-time videos) are presented and their performances discussed. Additionally, an algorithm for a highly accurate segmentation of detected near-duplicate fragments is presented.

TM2.2 P0619 1330 - 1350
A Systematic Approach for Rapid 3D Reconstruction from Photosets
Hoai Nam LE TRAN, Sornum Kabilen KADIRVELEN, Hock Soon SEAH, Wentong CAI, Malcolm Yoke Hean LOW, Suiping ZHOU, Michael Harold LEES
Nanyang Technological University

We present an interactive framework for rapid 3D reconstruction of objects from sets of photographs. Our framework implements advanced 2D image-based modeling techniques that accurately compute geometries of digital photo-realistic 3D models in a rapid and robust method. It is implemented in an application tool to assist users to perform feature detection, matching and meshing. Our system demonstrates that with a few user’s intervention through our application tool, efficient generation of 3D object models can be generated from a set of photos.

TM2.3 P0713 1350 - 1410
Image Segmentation of UV Pattern for Automatic Paper-Money Inspection
Keon-Ho LEE, Tae-Hyoun PARK
Chungbuk National University

We propose an image segmentation method for automatic paper-money inspection system. The UV (ultra violet) patterns embedded in the paper money should be segmented to determine whether the money is genuine or not. We acquire the image by directional lighting system using UV LEDs. In order to segment the pattern from the background, we apply the Gaussian mixture model to consider the multi-modal characteristics of the histogram. Experimental results are presented to verify the performance of the proposed method.

TM2.4 P0731 1410 - 1430
Fruit Detection, Tracking, and 3D Reconstruction for Crop Mapping and Yield Estimation
Jednipat MOONRINTA, Supawadee CHAIIVIVATRAKUL, Matthew N DAILEY, Mongkol EKPANYAPONG
Asian Institute of Technology

Through automated agricultural inspection, farmers can potentially achieve better productivity and accurately predict yields and crop quality. A variety of sensors can be used for agricultural inspection, but the cheapest and most information-rich is the video camera. We collect data in the field from a monocular camera fixed to a mobile inspection platform. For purposes of pineapple crop mapping and yield prediction, we propose an image processing framework for in-field fruit detection, tracking, and 3D reconstruction. We perform a series of experiments on feature point extraction using Harris, SIFT, and SURF features, feature point description using SIFT and SURF descriptors, feature point classification using SVMs, fruit region tracking using blob tracking, and 3D reconstruction using structure from motion and robust ellipsoid estimation techniques. We find that SURF feature points and descriptors provide the best tradeoff between processing time and classification accuracy and that the method is sufficiently accurate for fruit region detection. Our preliminary results for fruit region tracking and 3D fruit reconstruction are promising. We plan further work towards development of a useful aid to help farmers manage their farms.

TM2.5 P0755 1430 - 1450
Applying Training Hidden Features to Joint Curve Evolution for Brain MRI Segmentation
Mahshid FARZINFAR, Eam Khwang TECH, *Zhong XUE
Nanyang Technological University
*Weill Medical College of Cornell University

According to the level of information provided in images, segmentation techniques can be categorized
into two groups. One is region-labeling, which obeys the intensity-based classification methods. Although modeling the tissue intensity is straightforward by applying local statistical methods and spatial dependencies, the results might suffer from noise and incomplete data. The second group of techniques applies active contour models, in which the objective is to find the optimal partition of the image domain using a closed or open curve by using prior constraints on the shape variation. However, estimating optimal curve is intractable due to the incomplete observation data. This paper extends a previously reported joint active contour model for medical image segmentation in a new Expectation-Maximization (EM) framework, wherein the evolution curve is constrained not only by a shape-based statistical model but also by applying a hidden variable model from the image observation. In this approach, the hidden variable model is defined by the local voxel labeling computed from its likelihood function, depended on the image functions and the prior anatomical knowledge. Comparative results on segmenting putamen and caudate shapes in MR brain images confirmed both robustness and accuracy of the proposed curve evolution algorithm.

**Session TM6**

**Date:** Thursday, 09 December 2010  
**Time:** 1310 - 1510  
**Venue:** Oriole

**Computational Intelligence in Vision**

**Chairs:** Eric SUNG  
Nanyang Technological University

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**TM6.1 P0351 1310 - 1330**

**Profit of Extending Standard Relational Databases with the Intelligent Cluster Index (ICIx)**

Sebastian LEUOTH, Alexander ADAM, *Wolfgang BENN  
Dimensio Informatics GmbH  
*Chemnitz University of Technology

In this paper, we present a strategy to reduce the processing time needed for selection operations with many attributes in standard database systems. These problems mostly occur in data mining, data analysis, information retrieval, and applications with high combinatorial complexity. In these systems, standard indexes do not gain a satisfying performance. Currently, this problem is tackled using more computing power or special solutions instead of standard databases. Our approach is to interpret the queries as high-dimensional point or range queries. Thus, we provide a “real” solution to answering complex queries rather than merely postponing the problems using technical methods. We show the benefit of multi-dimensional data structures. This benefit can be transferred to a lot of applications (e.g. Business Intelligence, Bill Of Materials Explosion, DNA Sequence Search), not only advanced applications of database systems like GIS, CAD, or multimedia. Finally, a very small sample data set is used to show the profit of our approach and we present possible integration points of the ICIx into standard relational database.

**TM6.2 P0495 1330 - 1350**

**Ensembles of Novel Visual Keywords Descriptors for Image Categorization**

Azizi ABDULLAH, *Remco C VELTKAMP, **Marco A WIERING  
Universiti Kebangsaan Malaysia  
*Utrecht University  
**University of Groningen

Object recognition systems need effective image descriptors to obtain good performance levels. Currently, the most widely used image descriptor is the SIFT descriptor that computes histograms of orientation gradients around points in an image. A possible problem of this approach is that the number of features becomes very large when a dense grid is used where the histograms are computed and combined for many different points. The current dominating solution to this problem is to use a clustering method to create a visual codebook that is...
exploited by an appearance based descriptor to create a histogram of visual keywords present in an image. In this paper we introduce several novel bag of visual keywords methods and compare them with the currently dominating hard bag-of-features (HBOF) approach that uses a hard assignment scheme to compute cluster frequencies. Furthermore, we combine all descriptors with a spatial pyramid and two ensemble classifiers. Experimental results on 10 and 101 classes of the Caltech-101 object database show that our novel methods significantly outperform the traditional HBOF approach and that our ensemble methods obtain state-of-the-art performance levels.

**TM6.3 P1045 1350 - 1410**  
**Real-Time Dense Digital Elevation Map Estimation using Laserscanner and Camera SLAM Process**  
Florent MALARTRE, *Pierre DELMAS, Roland CHAPUIS, *Christophe DEBAIN  
Blaise Pascal University  
*Cemagref  

This paper is about environment perception for navigation system in outdoor applications. Unlike other approaches that try to detect an obstacle of binary state, we consider here a Digital Elevation Map (DEM). This map has to be built in regards to the guidance system's needs. These needs depend on the vehicle capabilities, its dynamics constraints, its speed etc... Starting with the navigation system's needs, our goal is to estimate a precise and dense DEM. Our approach is based on a SLAM algorithm combining a 2D rangefinder and a camera. Thus we can estimate both the displacement between two laser scan and have a good density of the reconstructed DEM. The approach has been validated both using simulated realistic data and real data in real-time on our robot in outdoor environment (approx. 40ms per loop).

**TM6.4 P1056 1410 - 1430**  
**A New SOM-based Active Contour Model using Conscience and Archiving Mechanisms**  
Fereshteh SADEGHI, Hamid IZADINIA, Reza SAFABAKHSH  
Amirkabir University of Technology, Tehran  

Active contour models are widely used in extracting object boundaries. However, most of these methods usually fail to capture concave boundaries properly and impose high computational cost. In this paper, a new SOM-based active contour model which introduces the Conscience and Archiving mechanisms (CASOM) is proposed to extend the Batch SOM method and eliminate its deficiencies. The performance of the proposed method is evaluated by some experiments on a set of grayscale images. Experimental results are compared with those of the BSOM in terms of accuracy and convergence speed. The results reveal that compared to BSOM, the proposed method requires less computations for converging to the object boundaries and extracts the boundaries of complex objects more accurately, even in the presence of weak or broken edges.

**TM6.5 P0540 1430 - 1450**  
**Color Rank and Census Transforms using Perceptual Color Contrast**  
Guangming XIONG, Xin LI, Jianwei GONG, Huiyan CHEN, *Dah-Jye LEE  
Beijing Institute of Technology  
*Brigham Young University  

Rank and census transforms provide high resistance to radiometric distortion, vignette, and noise because they are based on the relative ordering of local pixel intensity values rather than the pixel values themselves. These transforms are widely used in many computer vision applications. An important step of computing these transforms is to compare or rank two grayscale values, which is very much like measuring color difference in color image. Color difference between two color points at any part of a uniform color space corresponds to the perceptual difference between the two colors by the human vision system. Based on this idea, we propose to use perceptual color contrast to implement color rank and census transforms and achieve this without significantly increasing the amount of data to process and without complicated computations. Furthermore, we demonstrate the feasibility of using these new transforms to find correspondences for stereo vision.

**TM6.6 P0895 1450 - 1510**  
**Stereo for Robots: Quantitative Evaluation of Efficient and Low-memory Dense Stereo Algorithms**  
Federico TOMBARI, Stefano MATTOCCIA, Luigi DI STEFANO  
University of Bologna  

Despite the significant number of stereo vision algorithms proposed in literature in the last decade, most proposals are notably computationally demanding and/or memory hungry so that it is unfeasible to employ them in application scenarios requiring real-time or near real-time processing on platforms with limited resources such as embedded devices. In this paper, we have selected the subset of proposals that appears more suited to the above requirements and, since literature lacks a proper comparison between these methods, we propose a quantitative experimental evaluation aimed at highlighting the best performing approach under the two criteria of accuracy and efficiency. The evaluation is performed on a standard benchmark dataset as well as on a novel dataset, acquired by means of an active technique, characterized by realistic working conditions.
This paper investigates the joint effects of agent dynamic and network topology on the consensusability of linear discrete-time multi-agent systems via relative output feedback. An observer-based distributed control protocol is proposed. A necessary and sufficient condition for consensusability under this control protocol is given, which explicitly reveals how the intrinsic entropy rate of the agent dynamic and the eigenratio of the undirected communication graph affect consensusability. As a special case, the discrete-time double integrator system is discussed where a simple control protocol directly using the two-step relative position feedback is provided to reach a consensus. The theoretic results are illustrated by a simulation example.

This paper presents several analysis of mutual information that is often used to define the objective function for trajectory planning (and scheduling) of sensor networks, when the goal is to improve the forecast accuracy of some quantities of interest. The approach extends the present author's prior work in order to consider more general notion of verification entities and to enable more robust decision with potential uncertainty in the mission specifications. The expression of mutual information for windowed forecasting, in which the verification entities are defined by a finite time window instead of a single time instance, is derived and quantified without adding significant computational cost. It is also demonstrated that the sensitivity of mutual information to the variation of verification time can be calculated in the same process of computing the mutual information. Simple numerical examples are presented for preliminary validation of the applicability of the proposed analysis.
Session TP2 - Invited Session

Date: Thursday, 09 December 2010
Time: 1600 - 1740
Venue: Canary

Advances in Biometric Theory and Applications III

Chairs: Kar-Ann TOH, Yonsei University
Wei Yun YAU, Institute for Infocomm Research

TP2.1 P0798 1600 - 1620
A Projection Framework for Biometric Scores Fusion
Kar-Ann TOH, Yonsei University

This paper presents a projection framework for biometric scores fusion. Essentially, the framework consists of a projection stage and a learning stage. Apart from investigating into several relatively new projection models for biometric fusion, the projection stage attempts to unify these models into a single parametric structure. Three learning methods are investigated in conjunction with six projection models for their impacts on verification accuracy expressed in terms of equal error rate. An extensive experiment of these models and learning combinations on 32 fusion data sets are performed in the evaluation.

TP2.2 P1132 1620 - 1640
Design and Implementation of a Contactless Palm Print and Palm Vein Sensor
Kah Ong Michael GOH, Connie TEE, *Andrew Beng Jin TEOH, Multimedia University
*Yonsei University

This paper presents an innovative contactless palm print and palm vein recognition system. We design a hand sensor that could capture the palm print and palm vein image using low-resolution web camera. Both the visible and infrared images can be captured at the same time, and we do not need specialized infrared sensor to image the vein pattern. The design of the device is simple and low-cost. The subject can be shielded completely from the complication of undergoing two separate acquiring processes. We allow subjects to position their hands freely above the sensor and they can move their hands during the acquisition process. In order to obtain clear image of the palm vascular pattern, we propose a novel image enhancement technique called local-ridge-enhancement (LRE). The proposed method removes illumination error while keeping good contrast between the print/vein pattern and the background image. Besides, we introduce a simple yet robust directional coding technique to encode the palm print and palm vein features in bit string representation. The bit string representation offers speedy template matching and enables more effective template storage and retrieval. The scores output by the palm print and palm vein experts are fused using Support Vector Machine. The fusion of these features yields promising result for practical implementation.

TP2.3 P1149 1640 - 1700
A Metric of Identification Performance of Biometrics based on Information Content
Seira HIDANO, Tetsushi OHKI, Naohisa KOMATSU, *Kenta TAKAHASHI, Waseda University
*Hitachi Ltd.

We propose the minimum distance entropy (MDE) as a metric of biometric information content. The MDE is the probability that two biometric samples correspond exactly expressed in information content and can be calculated through the experiment for interpersonal matching using a set of biometric samples. This metric makes it possible for certain biometrics not only to be compared with other biometrics but also to be partially compared with personal authentication using passwords, PIN, or other methods in regard to the identification performance or the security. In this paper, we discuss the metric in terms of information theory and show how to evaluate it. Then, as an example, we apply it to a fingerprint system and evaluate fingerprint information content through simulations.

TP2.4 P0719 1700 - 1720
A Comparative Study of Local Feature Extraction for Age Estimation
Sung Eun CHOI, Youn Joo LEE, Sung Joo LEE, *Kang Ryoung PARK, Jaihie KIM, *Dongguk University
*Yonsei University

Many age estimation methods have been proposed for various applications such as Age Specific Human Computer Interaction (ASHCI) system, age simulation system and so on. Because the performance of the age estimation is greatly affected by the aging feature, the aging feature extraction from facial images is very important. The aging features used in previous works can be divided into global and local features. As global features, Active Appearance Models (AAM) was mainly used for age estimation in previous works. However, AAM is not enough to represent local features such as wrinkle and skin. Therefore, the research about local features is required. In previous works, local features were generally used to determine age group rather than detailed age, and the comparative studies about various local features extraction methods were not conducted. In this paper, the performances of sobel filter, difference image between original and smoothed image, ideal high pass filter (HPF), gaussian high pass filter (GHPF), Haar and Daubechies discrete wavelet transform (DWT) are compared for extracting local features and detailed age estimation is performed by Support Vector Regression (SVR) on BERC and PAL aging database. The experimental results show that local features can...
be used for detailed age estimation and GHPF gives a better performance than other methods.

**TP2.5 P0726 1720 - 1740**

Dynamic Detection Rate-based Bit Allocation for Biometric Discretization
Meng-Hui LIM, Beng Jin Andrew TEOH
Yonsei University

Biometric discretization converts extracted biometric features into a binary string via a process of segmenting every one-dimensional feature space into possibly distinct multiple intervals and encoding every interval-captured feature element correspondingly. Eventually, the individual binary output of every feature element is concatenated into a binary string. To the best of our knowledge, Detection Rate Optimized Bit Allocation (DROBA) scheme is currently the most effective biometric quantization scheme, offering its capability in assigning bits dynamically for each user-specific feature. However, we discover that DROBA suffers from potential discriminative feature miss-detections and under-quantized conditions. This paper highlights such drawbacks and improves upon DROBA by incorporating a dynamic searching method to efficiently recapture such miss-detected features. Experimental results illustrating significant improvements in classification accuracy justify the practicality of our approach.

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**Session TP3**

**Date:** Thursday, 09 December 2010  
**Time:** 1600 - 1800  
**Venue:** Kingfisher

**Robust Control II**

**Chair:** Janardhanan SIVARAMAKRISHNAN  
*Indian Institute of Technology, Delhi*  
Krzysztof J LATAWIEC  
*Opole University of Technology*

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**TP3.1 P0380 1600 - 1620**

Reaching Law Based Sliding Mode Control for Discrete MIMO Systems
Mija S J, Susy THOMAS  
National Institute of Technology Calicut

This paper analyzes the effectiveness of the reaching law approach for sliding mode control of discrete time systems. The method is extended for sliding mode control for multi-input multi-output (MIMO) systems. Modified reaching law for reducing the chattering is proposed. The performance of the proposed controller is analyzed by carrying out simulation studies on MIMO systems. The performance of the controller is also compared with that of the equivalent control.

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**TP3.2 P0386 1620 - 1640**

Design of Multirate Output Sampling based Linear Functional Observer and State Feedback
Janardhanan SIVARAMAKRISHNAN, Neeli SATYANARAYANA  
*Indian Institute of Technology, Delhi*

This paper addresses the problem of realizing a pre-defined linear function of a state using multirate sampling for the purpose of implementing state feedback control law. For that, the functional should be expressed as a linear combination of output vector constructed by sampling system output at faster rate. This method can also be applied for systems having unobservable modes. The proposed method has the advantage that the number of output samples required can be less than the observability index. Numerical example is considered to illustrate the procedure of proposed method.

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**TP3.3 P1020 1640 - 1700**

Right/Left Inverses of Polynomial Matrices for Control, Communications and Vision
Wojciech P HUNEK, Krzysztof J LATAWIEC, Marian LUKANISZYN  
*Opole University of Technology*

This paper reviews various right/left inverses of polynomial matrices, introduced by the authors as a result of their research works on minimum variance control for LTI MIMO systems. In consequence, a new, general, Smith-factorization based inverse is
presented. The problem of selection of stable inverses, in particular pole-free inverses, is also tackled. Applications in control, communications and vision, in particular concerning perfect signal transmission/recovery, are indicated.

**TP3.4  P0935  1700 - 1720**

Passivity-Preserving Frequency Weighted Model Order Reduction Techniques for General Large-Scale RLC Systems

Wan Mariam WAN MUDA, Victor SREERAM, Herbert Ho-Ching IU

University of Western Australia

This paper presents passivity-preserving frequency-weighted model order reduction (MOR) techniques for general large-scale RLC systems. Three techniques (Enns', Wang's and Lin and Chiu's) which preserve only stability and not passivity are generalized to include passivity in this paper. Conditions under which the passivity is preserved are also derived. Simulation results are also presented to show the effectiveness of the proposed generalization.

**TP3.5  P0673  1720 - 1740**

Automotive Driveline Control by a Nonlinear Nonparametric QFT Method

Ahmed Fahmy ABASS, Andrew Thomas SHENTON

University of Liverpool

A new nonlinear Quantitative Feedback Theory (QFT) methodology is presented and applied to the control of the automotive driveline with nonlinear clutch and backlash. A driveline model is presented which incorporates the nonlinear clutch characteristics and the coupling backlash realistically sandwiched by compliant inertias. The model gives responses that are representative of typical driveline systems, with the backlash accentuating the magnitude of oscillatory shuffle response. A Nonparametric (NP) identification method is given for directly developing the QFT templates of the Linear Time-Invariant Equivalent (LTIE) plant model set. The identification uses a Discrete Fourier Transform (DFT) to convert the system data to the frequency domain (FD). To mitigate against windowing errors the frequency response (FR) data is locally smoothed by a sliding frequency weighting function. The LTIE set is obtained as set of NP identified models obtained directly from typical vehicle experimental input-output test data. Non-minimum phase (NMP) QFT bounds are determined from the nominal NP plant by determining the Hilbert transform of the NMP plant. The controller design methodology is applied to the model and it is shown that predefined robust tracking and disturbance response performance specifications can be systematically obtained, without subsequent heuristic parameter tuning.

**TP3.6  P1058  1740 - 1800**

A Slightly Improved Robust Adaptive Observer for Actuator Fault Detection

Kamel MENIGHED, Joseph J YAME, Christophe AUBRUN

University Henri Poincare

In this paper, we address the problem of actuator fault detection and estimation for a plant in the presence of external disturbances. We design a robust fault estimation technique based on an adaptive observer with enhanced speed of adaptation. The construction of the observer is carried out through a transformation of the plant model into its special coordinate basis (SCB) form. This transformation allows a decoupling of the fault estimates from the disturbances. Thanks to this decoupling, the standard adaptive observer is slightly modified to achieve faster fault estimation in presence of disturbances and plant-model uncertainties. Simulation experiments are presented to illustrate the effectiveness of the proposed adaptive scheme.
Session TP4 - Invited Session
Date: Thursday, 09 December 2010
Time: 1600 - 1800
Venue: Nightingale

Intelligent Diagnosis and Prognosis
Chairs: Junhong ZHOU
Singapore Institute of Manufacturing Technology

TP4.1 P0923  1600 - 1620
An exTS based Neuro-Fuzzy Algorithm for Prognostics and Tool Condition Monitoring
Olivier MASSOL, *Xiang LI, Rafael GOURIVEAU,
*Junhong ZHOU, *Oon Peen GAN
Université de Franche Comté
*Singapore Institute of Manufacturing Technology

The growing interest in predictive maintenance makes industrials and researchers turning themselves to artificial intelligence methods for fulfilling the tasks of condition monitoring and prognostics. Within this frame, the general purpose of this paper is to investigate the capabilities of an Evolving extended Takagi Sugeno (exTS) based neuro-fuzzy algorithm to predict the tool condition in high-speed machining conditions. The performance of evolving Neuro-Fuzzy model is compared with an Adaptive Neuro-Fuzzy Inference System (ANFIS) and a Multiple Regression Model (MRM) in term of accuracy and reliability through a case study of tool condition monitoring. The reliability of exTS also investigated.

TP4.2 P0924  1620 - 1640
A Knowledge Base System for Rotary Equipment Fault Detection and Diagnosis
Junhong ZHOU, *Yen Tat, Louis WEE, *Zhao Wei ZHONG
Singapore Institute of Manufacturing Technology
*Nanyang Technological University

This paper studies the fault detection and diagnosis for the most common faults in the rotary equipment. Large amount of experiments are carried out on the machinery fault simulator for simulating different types of rotary machine faults. The study covers from different type of data acquisition sensors, different signal processing and feature extraction techniques. A hierarchical rule-based fault detection system which comprises of a knowledge base coupled with an inference engine is proposed. The knowledge-base that maps the fault mode to signal processing and detection methods is built up. The rule-based fault detection system capable of assisting mechanics and engineers to deal with fault diagnosis of the rotary equipment is presented.

TP4.3 P0962  1640 - 1700
FDI and Fault Estimation based on Differential Evolution and Analytical Redundancy Relations
Ming YU, Danwei WANG, *Ming LUO, *Danhong ZHANG
Nanyang Technological University
*Singapore Institute of Manufacturing Technology

This article studies fault detection and isolation (FDI) and fault estimation in complex hybrid systems. The FDI approach is based on a set of unified constraints, called augmented Global Analytical Redundancy Relations (AGARRs), to detect and isolate the faults. In order to estimate the magnitude of the fault parameter, the fault candidates, a differential evolution (DE) method is employed. This developed method is applicable to estimation of multiple faults of parametric and nonparametric nature. Simulation is carried out to verify the effectiveness of the proposed method in a front steering system of a CyCab mobile robot with multiple faults.

TP4.4 P0977  1700 - 1720
Continuous Health Assessment using a Single Hidden Markov Model
Omid GERAMIFARD, Jianxin XU, *Junhong ZHOU, *Xiang LI
National University of Singapore
*Singapore Institute of Manufacturing Technology

In this paper, two temporal models, Hidden Markov Model and Auto Regressive Moving Average model with exogenous inputs (ARMAX), are used for health condition monitoring of the cutter in a milling machine. Dataset is acquired through real time force signal sensing. A heuristic statistical approach is used to select dominant features, leading to the selection of 3 dominant features from the 16-dimensional feature space. Subsequently Hidden Markov Model and ARMAX model have been trained to predict the wearing status of the cutter in the milling machine. Suitability of these approaches are investigated and compared.

TP4.5 P1115  1720 - 1740
Towards Machine Diagnostics on Chip
Shen-Hoong ONG, Kiah-Mok GOH, Hian-Leng CHAN,
*Teck-Yian LIM, *Keck Voon LING
Singapore Institute of Manufacturing Technology
*Nanyang Technological University

Failures of critical factory equipment are one of the main reasons for production stoppages and a regular maintenance schedule is required to ensure continuous operation of production line. However, regular maintenance can be both costly and inefficient. Vibrations are present in all machinery with moving parts and it had always been regarded as an indicator of the health and condition of rotating machinery. With advances in technology, what used to be a mechanic’s hunch can now be measured and with reasonable accuracy. This paper present a proof-of-concept implementation of machine diagnostic on chip using an intelligent wireless sensor node, capable of processing and analyzing vibration signals from Micro-electromechanical (MEMS) sensors. Special design considerations were also made to allow the wireless sensor node to be
reconfigurable and modular at both the hardware and software level. A custom fixed-point library was implemented to tackle accuracy issues in dealing with small numbers without the use of floating point numbers in resource scarce platforms.

TP4.6 P1128 1740 - 1800
Flute based Analysis of Ball-Nose Milling Signals using Continuous Wavelet Analysis Features
Amin TORABI JAHROMI, *Olivier MASSOL, Meng Joo ER, **Xiang LI, **Beng Siong LIM, **Oon Peen GAN, **Sheng HUANG, et al
Nanyang Technological University
*Université de Franche Comte
**Singapore Institute of Manufacturing Technology

Surface Finishing and End Milling are among the most sophisticated manufacturing processes. For the industry to improve the quality of its end-line products, it is important for improving the performance of these processes by having a descriptive reference mode. Using this reference model, non-intrusive prediction of the resulting surface quality and the tool status can be accurately conducted. Many modeling techniques have been used in literature. Since there are no reports of success on a general model that support all the tool specifications, cutting conditions and correlation of the too-health, cutting signals and resulting surface roughness or tool-wear, the researches based on the severable available AI techniques and different sensor signals and there features are ongoing. This paper investigates the existing correlation between the resulted wavelet coefficients and ball-nose tool-wear using Cascaded Feed Forward Neural Networks (CFFNN). Considering the changes in the shape of the signals during the cutting process and the similarity of the resulting signals during the cutting process and the similarity of the resulting signals to some mother wavelets and the lack of literature on wavelet analysis for ball-nose cutters’ signals, this specific analysis is chosen. CFFNN is also selected for its capability to deal with a non-linear process and being comparatively simple. The results are satisfying with the proposed structure. More studies for the optimal structure and features are expected in the future.

Session TP5 - Invited Session
Date: Thursday, 09 December 2010
Time: 1600 - 1800
Venue: Pelican

Variable Structure Control Systems
Chairs: Suiyang KHOO
Deakin University

TP5.1 P1089 1600 - 1620
Natural Logarithm Sliding Mode Control (In-SMC) using EMRAN for Active Engine Mounting System
Andika Aji WIJAYA, Wahyudi MARTONO, Rini ANMELAWATI, Fadly Jashi DARSIVAN
International Islamic University Malaysia

Robustness of the controller becomes major important factor in active engine mounting system to ensure the vibration of the engine can be attenuated in entire range of operating speed. As robustness is the main advantage of sliding mode control, it has been proposed for vibration control applications. However, most of the proposed sliding mode control are using linear sliding surface. In this paper, natural logarithm-based sliding function is introduced. By its nature, natural logarithm function is nonlinear function. Since it consists of one parameter only, which is related to maximum allowable vibration level, it is more easily to be determined by the designer. Moreover, the advantage of fast on-line training using Extended Minimum Resource Allocating Network (EMRAN) algorithm, made it possible to design feedback control law without having to obtain the precise system model which is normally becomes major difficulties of sliding mode approach.

TP5.2 P1099 1620 - 1640
Convergence Accuracy Analysis of Discretized Sliding Mode Control Systems
Bin WANG, Xinghuo YU, Liuping WANG
RMIT University

In this paper, the convergence accuracy of system states in discretized sliding mode control (SMC) systems is thoroughly analyzed using big O notation. It confirms that for a n-th order system, system states x1, x2, ..., xn have different convergence rates.

TP5.3 P1118 1640 - 1700
Navigation of Four-Wheel-Steering Mobile Robots using Robust Fault-Tolerant Sliding Mode Control
Madushanka Nishan DHARMAWEERA, *Suiyang KHOO, **Zhihong MAN
Monash University, Sunway Campus
*Deakin University
**Swinburne University of Technology
This paper addresses the leader-follower tracking problem of a four-wheel-steering robot subjected to nonlinear uncertainties. Two control laws have been developed, based on the adaptive sliding mode method and the adaptive input-output feedback linearization method. The proposed control schemes have been tested by means of simulations.

TP5.4 P1145 1700 - 1720
Leader-follower Consensus Control of a Class of Nonholonomic Systems
Suiyang KHOO, *Lihua XIE, **Zhihong MAN
Deakin University
*Nanyang Technological University
**Swinburne University of Technology

In this paper, we propose a systematic solution to the leader-follower consensus of a class of nonholonomic chained form systems. The control design, which is reminiscent of terminal sliding mode and multi-surface sliding mode control methods, is presented to guarantee the convergence of multiple sliding surfaces, which also implies the convergence of the proposed consensus error function. On these sliding surfaces, the desired leader-follower consensus can be reached for multi-agent network formed by the nonholonomic chained form systems.

TP5.5 P1047 1720 - 1740
Quantization of Optimal Control System & Synthesis of Optimal Controls of Quantum Diffusion Process
Balai Chandra ROY
Calcutta University

When applied quantization to classical control system, quantum mechanics opens completely new perspectives; by exploiting quantum mechanical features, such as, time evolution of quantum state and costate (generalized momenta) of the Hamiltonian of the system, one can formulate and solve the optimal control problems of the quantum mechanical system more efficiently than the classical system. The physical perspective of quantization of the optimal feedback system is outlined by exploiting the formulation of the optimization problem of the system within the context of Hamilton-Jacobi theory and Pontryagin maximum/minimum principle in abstract Hilbert space. One of the most striking example is the optimal control problem of synthesizing the feedback law of quantum diffusion process. The optimal diffusion process is shown to satisfy the Schrödinger wave equation of energy with the feedback law as potential function.

TP5.6 P0263 1740 - 1800
A Nonlinear Exponential Observer for a Batch Distillation
Amiya K JANA
Indian Institute of Technology, Kharagpur

In this contribution, a state observer, namely nonlinear exponential observer (NEO) is proposed for a batch distillation process. This estimation scheme mainly computes the imprecisely known parameter (augmented state) based on the available measurement. For the representative distillation unit, the state predictor is formulated on the basis of only a component material balance equation around the condenser-reflux drum system. It clearly indicates the existence of a process/model mismatch and the effect of this discrepancy is efficiently taken care of by the corrector part of the NEO estimator. Several simulation experiments have been executed to show the observer error convergence ability. The less computational requirements and simple design make the closed-loop observer attractive for online use.
Session TP6 - Invited Session

Date: Thursday, 09 December 2010
Time: 1600 - 1800
Venue: Oriole

**Autonomy of Vehicular Systems I**

Chairs: Christian LAUGIER
INRIA
Philippe MARTINET
Clermont Université

TP6.1 P0502 1600 - 1620
A Real-Time Robust Global Localization for Autonomous Mobile Robots in Large Environments
Jianping XIE, *Fawzi NASHASHIBI, Michel PARENT, **Olivier GARCIA FAVROT
INRIA
*Mines ParisTech
**INDUCT Company

Global localization aims to estimate a robot’s pose in a learned map without any prior knowledge of its initial pose. Achieving highly accurate global localization remains a challenge for autonomous mobile robots especially in large-scale unstructured outdoor environments. This paper introduces a real-time reliable global localization approach with the capability of addressing the kidnapped robot problem using only laser sensors. Our approach includes four steps: 1) local Simultaneous Localization and Mapping 2) map matching 3) position tracking and 4) localization quality evaluation. For sensor perception, we use occupancy grid method to represent robot environment. A novel pyramid grid-map based coarse-to-fine matching approach is proposed to improve the localization accuracy. Experimental results including an outdoor environment of 25,000 m² are presented to validate the feasibility and reliability of the proposed approach.

TP6.2 P0511 1620 - 1640
The ArosDyn Project: Robust Analysis of Dynamic Scenes
Igor E PAROMTCHIK, Christian LAUGIER, Mathias PERROLLAZ, Yong MAO, Amaury NEGRE,
*Christopher TAY
INRIA
*ProBayes

The ArosDyn project aims to develop embedded software for robust analysis of dynamic scenes in urban traffic environments, in order to estimate and predict collision risks during car driving. The on-board telemetric sensors (lidars) and visual sensors (stereo camera) are used to monitor the environment around the car. The algorithms make use of Bayesian fusion of heterogenous sensor data. The key objective is to process sensor data for robust detection and tracking of multiple moving objects for estimating and predicting collision risks in real time, in order to help avoid potentially dangerous situations.

TP6.3 P0655 1640 - 1700
Detection of Unfocused Raindrops on a Windscreen using Low Level Image Processing
Fawzi NASHASHIBI, Raoul DE CHARETTE, Alexandre LIA
Mines ParisTech

In a scene, rain produces a complex set of visual effects. Obviously, such effects may infer failures in outdoor vision-based systems which could have important side-effects in terms of security applications. For the sake of these applications, rain detection would be useful to adjust their reliability. In this paper, we introduce the problem (almost unprecedented) of unfocused raindrops. Then, we present a first approach to detect these unfocused raindrops on a transparent screen using a spatio-temporal approach to achieve detection in real-time. We successfully tested our algorithm for Intelligent Transport System (ITS) using an on-board camera and thus, detected the raindrops on the windscreen. Our algorithm differs from the others in that we do not need the focus to be set on the windscreen. Therefore, it means that our algorithm may run on the same camera sensor as the other vision-based algorithms.

TP6.4 P0684 1700 - 1720
Visibility Distance Estimation based on Structure from Motion
Clément BOUSSARD, *Nicolas HAUTIERE, **Brigitte D’ANDRÉA-NOVEL
INRIA
*LCPC
**Mines ParisTech

It is obvious to say that perception is necessary to drive. Furthermore we can say that a good visibility is a guaranty for passengers security. The driver will adapt the vehicle speed to the offered visibility. Strong visibility reductions (dense fog for instance) are conditions of risk of accident. We therefore propose here a method to perform an onboard estimation of the visibility distance. Once this estimate is obtained, assistance could be offered to the driver (eg if it runs at a speed not adapted to the current visibility) or to the road infrastructure management so that it can inform other users of risk on his road network. This method uses images acquired by an onboard camera filming the scene and the estimation of vehicle motion. Thus, from this information we will explain how we can achieve a spatial partial structure reconstruction to estimate the visibility distance.

TP6.5 P0770 1720 - 1740
Collaborative Multi-Vehicle Localization and Mapping in High Clutter Environments
Moratuwage M.D.P., Wijerupage Sarda WIJESOMA, Bharath KALYAN, *Nicholas M PATRIKALAKIS, Peyman MOGHADAM
Nanyang Technological University
Among today’s robotics applications, exploration missions in dynamic, high clutter and uncertain environmental conditions is quite common. Autonomous multi-vehicle systems come in handy for such exploration missions since a team of autonomous vehicles can explore an environment more efficiently and reliably than a single autonomous vehicle (AV). In order to improve the navigation accuracy, especially in the absence of a priori feature maps, various simultaneous localization and mapping (SLAM) algorithms are widely used in such applications. As for multi-vehicle scenarios, collaborative multi-vehicle simultaneous localization and mapping algorithm (CSLAM) is an effective strategy. However use of multiple AVs poses additional scaling problems such as inter-vehicle map fusion, and data association which needs to be addressed. Although existing CSLAM algorithms are shown to perform quite adequately in simulations, their performance is much less to be desired in high clutter scenarios that is inevitable in actual environments. In this paper, we present an approach to improve the performance of a CSLAM algorithm in the presence of high clutter, by combining an effective clutter filter framework based on Random Finite Sets (RFS). The performance of the improved CSLAM algorithm is evaluated using simulations under varying clutter conditions.

Session TP7
Date: Thursday, 09 December 2010
Time: 1600 - 1800
Venue: Bluebird

Visual Servoing
Chairs: Wen-Chung Chang
National Taipei University of Technology
Jorge Pomares
University of Alicante

TP7.1  P0396  1600 - 1620
Direct Visual Servo Control of a Robot to Track Trajectories in Supervision Tasks
Gabriel J Garcia, Carlos A Jara, Jorge Pomares, Fernando Torres
University of Alicante

TP7.2  P0507  1620 - 1640
Visual Servoing using Triangulation with an Omnidirectional Multi-Camera System
Bernhard Weber, Kolja Kühnlenz
Technische Universität München

TP7.3  P0560  1640 - 1700
Vision-Based Path Planning with Obstacle Avoidance for Mobile Robots using Linear Matrix Inequalities
Weifeng Huang, *Anan Osotshils, Farzad Pourbohvat
Southern Illinois University, Carbondale
*Assumption University
In this paper, a vision-based obstacle avoiding path generation problem is considered for autonomous mobile robots under a top-view workspace. The collision-free path planning problem is converted to a convex optimization problem that can be solved numerically using linear matrix inequalities (LMI). A new optimal (shortest) path cost formulation is given for LMI optimization using a novel Line of Sight Meshing (LSM) method. As compared to the traditional meshing algorithms such as Voronoi and Delaunay, the LSM generates fewer mesh cells which results in reduced computation time. A virtual path diagram (VPD), consisting of all collision-free piecewise straight-line paths, is then found for robot navigation. The LMI optimization method is then used to find the optimal (shortest) collision-free path from the VPD set. In addition to distance, other constraints, such as terrain condition and curvature of the path can be incorporated in the cost function for constrained optimal solution. Finally, a rapid prototyping (RP) environment has been developed, which is used for hardware implementation of the algorithm. The generated paths are then converted to motion commands, which are sent wirelessly from a base-station to mobile robots for motion control.

TP7.4  P0611  1700 - 1720
An Intelligent Space for Mobile Robot Navigation with On-Line Calibrated Vision Sensors
Wen-Chung CHANG, Ping-Rung CHU
National Taipei University of Technology

This paper presents a seemingly novel approach to accomplishing mobile robot localization and navigation in a large unknown workspace with a set of vision sensors based on an effective on-line calibration strategy. Each adjacent IP camera pair for visual sensing is assumed to have an overlapping field of view, but the positions as well as orientations with respect to either the Cartesian space or the mobile robot are unknown. The idea is to control the mobile robot to actively perform calibration with any stationary IP camera that can observe the five pre-selected color-coded features onboard the mobile robot, and thus establish coordinate transformations among these IP cameras. In particular, the coordinate transformation from the mobile robot to the IP camera is recursively updated based on all observed data and the kinematic model of the mobile robot. The proposed system only requires a PC and a network of stationary IP cameras without performing off-line calibration. Therefore, the proposed approach appears to be low-cost, effective, efficient, and flexible.

In this paper, we shed new light on PBVS (Position-Based Visual Servoing) by introducing the concept of a 3D (Dimension) visible set for PBVS, which can serve to play exactly the role of the 2D visible set, image plane, for IBVS. Our 3D visible set is convex even in the presence of uncertainties in intrinsic and extrinsic parameters of the camera, just as the image plane is a convex set. Then, we can ensure the FOV (Field of View) constraint simply by controlling the camera pose to follow a smooth straight-line trajectory in our 3D visible set for PBVS, which connects two points determined by the initial and desired poses of the camera. To demonstrate further the validity and practicality of our VS scheme, we also present various experimental results using a 6 degree-of-freedom robotic manipulator.

TP7.6  P0913  1740 - 1800
A Framework of Networked Visual Servo Control System with Distributed Computation
Haiyan WU, Lei LOU, Chih-Chung CHEN, Sandra HIRCHE, Kolja KÜHNLENZ
Technische Universität München

In this paper, a networked visual servo control system with distributed computation is proposed to overcome the low sampling rate problem in vision-based control systems. A real-time image data transmission protocol based on Realtime Transport Protocol (RTP) is developed. The captured images are sent to different processing nodes connected over a communication network and processed in parallel. Thus, a high sampling rate of the visual feedback is achieved under a cloud image processing architecture. The varying image processing delay caused by the varying number of extracted features and the random transmission delay are modeled as a random process with Bernoulli distribution. By using the input-delay approach, the resulted networked visual servo control system is reformulated into a stochastic continuous-time system with time-varying delay. Experiments on two 1-DoF linear motor modules are carried out to validate the proposed approach. A visual servo control system without parallel distributed computation is implemented for comparison. The experimental results demonstrate significant performance improvement by the proposed approach.

TP7.5  P0688  1720 - 1740
A Novel Position-Based Visual Servoing Approach for Robust Global Stability with Feature Points Kept within the Field-of-View
In-Joong HA, Do-Hwan PARK, Jeong-Hun KWON
Seoul National University
Session TI

Date: Thursday, 09 December 2010
Time: 0930 - 1800
Venue: Foyer

Interactive Session II

TI.1  P0247
Simple Analytic Formulas for PID Tuning
Wuhua HU, Gaoxi XIAO, Wen-Jian CAI
Nanyang Technological University

This paper proposes simple analytic formulas for proportional-integral-derivative (PID) controller tuning for typical process models. The formulas are obtained in a similar way to the simple internal model control (SIMC) tuning rules, while the leading analysis is more delicate. Compared to SIMC counterparts, the new tuning formulas lead to better load disturbance rejection while giving similar setpoint response and peak sensitivity.

TI.2  P0389
An Optimal Point-wise Control Method for Parabolic Distributed Parameter Systems
Qian LI, Ning LI, Shao-yuan LI
Shanghai Jiaotong University

An optimal point-wise control method for parabolic distributed parameter systems is proposed to solve the problem of determining both the locations of point-wise controllers and the control which should be exerted on each controller. For a given number of point-wise controllers, the optimal point-wise control form is given by solving a quadratic cost control problem, and the controller locations and the control are determined by minimizing the quadratic control cost performance index. The result indicates the method proposed is effective at solving the optimal point-wise control problem for parabolic distributed parameter systems.

TI.3  P0453
Decoupling the Control Variables of a Plant in Presence of Time Delay
Julian FUCHS, Ulrich KONIGORSKI
Technische Universität Darmstadt

In this contribution a concept is presented, which offers independent controllability of pressure and flow-rate within process plants. The dynamic of those plants is highly nonlinear and the control variables are coupled. Furthermore, time delays have to be considered. The proposed control concept consists of a nonlinear decoupling controller in combination with an extended smith predictor. The functionality of the controller is demonstrated by measurements on a test bench.

TI.4  P0572
Modelling of a Hot Water Drum and Heat Exchanger Process Control Training System
Belinda Chiew Meng CHONG, *Mohd Nor MOHD THAN
University Teknology MARA Malaysia
*University of Tun Hussein Onn

The purpose of this paper is to study a mathematical formulation of a water level and product liquid temperature control loop in a boiler drum and heat exchanger process control training system. Mathematical modeling was carried out to understand the dynamics of the liquid product temperature for different settings of PID controller mode. The modeling objective is to address the prediction of the plant performance with sufficient accuracy so that experimental data can be verified with the simulation results. The experimental data was obtained from the mini plant and the simulation results by model developed by using Simulink toolbox in Matlab software. The experimental and simulation results that were verified exhibited fair agreement.

TI.5  P0669
Fractional–Order Generalized Predictive Control: Formulation and some Properties
Miguel ROMERO, Angel P DE MADRID, Carolina MANOSO, *Blas M VINAGRE
Universidad Nacional de Educacion a Distancia
*University of Extremadura

This paper deals with the formal formulation of Fractional–Order Generalized Predictive Control, a generalization of GPC that makes use of fractional–order operators in its cost function. A thorough mathematical description of FGPC is given and the main similarities and differences between GPC and FGPC are highlighted.

TI.6  P1037
Harmonic Excitation Based Autotuning - Autotuning Usable for Control of Biomass Combustion Processes
Stanislav VRÁNA, Bohumil ŠULC
Czech Technical University in Prague

Controlling combustion processes is an important task, mainly with respect to energy efficiency and ecological impacts. This problem has become significant with the increased use of biomass-fired boilers, including low-power boilers. The combustion process is a process that we have limited information about. The equations for the chemical reactions are known, but in reality combustion of biomass is much more complicated and more variable than a mathematical model can express. It is therefore not simple to design a controller that is able to control the combustion process effectively in the whole range. Small-scale biomass-fired boilers are usually equipped with simple two-state (on/off) controllers. Many laboratories have attempted to develop a model of the combustion process suitable for controller setting and parameter adaptation, but the results are not yet satisfactory or generally valid. Thus, advanced model-based control strategies are
not usable, while the use of a model-free controller is not excluded if well-designed tuning rules can be provided. An approach which tries to satisfy most of the requirements of industrial practice is presented in this paper, which is based on an experimentally performed evaluation of small amplitude excited frequency responses with the aim to achieve recommended values of one or more control quality indicator known e.g. from the course of the Nyquist plot. The indicators can be evaluated experimentally in control loops involving nonlinearities. In this sense, the method has a philosophy similar to that of the popular Ziegler and Nichols method, but no interruption of the control process is necessary and the amplitude of the excited oscillation can be set by operator. The main advantages of the method presented here are: there is no use of any mathematical model, it can be used as an addition to the existing controller purely by software, and there is no need to interrupt the control process while retuning the controller.

TI.1.7  P0709
On-line Identification and Control Methods for PID Controllers

Utkal MEHTA, Somanath MAJHI
Indian Institute of Technology, Guwahati

The aim of this paper is to present a method for on-line tuning of PID controller for stable processes. Without breaking closed-loop control, an explicit process model is developed from a single relay test and then controller gains are re-tuned non-iteratively to improve the performance. An explicit tuning rules are derived with special emphasis on minimizing the control efforts. Examples are given to illustrate the simplicity and superiority of the proposed method compared with some existing ones.

TI.8  P0541
Shaping Nonlinear Modal Manifold of Internal Resonance System

Ta-ming SHIH
Ming Dao University

For system of internal resonance(IR) properties, there will be modal coupling effect while the system linear frequency is commensurable. In order to discuss the dynamic behavior on the IR manifold, we need to include all the coupling manifolds as one invariant manifold, by using the modal invariance property, the system energy can be constrained in this manifold. In this research, an extended normal form method is developed to study the nonlinear Internal Resonance normal mode. The method is based on the traditional normal form method in nonlinear dynamics analysis. By using the modal invariance property, we will form a set of homological equations; and the coordinate transformation process is converted to a coefficients-to-be-determined problem. The proposed method gives a clear view of the dynamic structures on each modal manifold, which is useful for analyzing some modal coupling phenomenal such as internal resonance (IR) or modal localization problem.

TI.9  P0565
Analysis and Application of Trajectory in Discrete-time System

Jianyin FANG, Kai LIU
Henan Institute of Engineering

In this work, we focus on the properties of trajectory in discrete-time system. under some conditions, the behavior of this class of systems' trajectory is studied. Using this properties, several characteristics of discrete-time system are also given, which is very helpful to study the ISS property of discrete-time system.

TI.10  P0639
Two Flat Normal Forms for a Class of Nonlinear Dynamical Systems

Bououden SORAYA, Boutat DRISS, *Abdessemed FOUDIL
PRISME-ENSI de Bourges
*University of Al Jouf

In this paper we presents two new 0-flat normal forms. It deals with sufficient geometrical conditions which enable us to conclude if a given nonlinear controllable dynamical system can be transformed, by means of change of coordinates, to one of these normal forms. In the same way it gives an algorithm to compute the flat outputs. As an illustration to the proposed approach, a trajectory tracking of a planar manipulator robot is simulated. The results obtained are very satisfactory proving the applicability of the method.

TI.11  P1068
Nonlinear Disturbance Decoupling for a Nonholonomic Mobile Robotic Manipulation Platform

Joel JIMENEZ-LOZANO, Bill GOODWIN
University of Notre Dame

A mobile manipulator is at the present time a widespread term to refer to robot systems built from a robotic manipulator arm mounted on a mobile platform. A mobile manipulation system offers a dual advantage of mobility offered by a mobile platform and dexterity offered by the manipulator. In this work, the tracking and nonlinear disturbance decoupling problems are studied. We show that this system posses the necessary geometric structure for complete disturbance decoupling between the outputs and disturbances. Simulation results obtained for the mobile manipulator show good performance in the presence of significant disturbances using the designed nonlinear controller.

TI.12  P0419
Real-time INS/GPS Data Fusion using Hybrid Adaptive Network Based Fuzzy Inference

Malleswaran M, Mary Anita J, Sabreen SN, *Vaidehi
Kalman filter is used to integrate the data from inertial navigation systems (INS) and global position systems (GPS) for vehicle navigation to provide position, velocity and attitude. However several drawbacks of Kalman filter such as noise, modeling of the system, initial noise parameter are restricted its application and implementation. In this paper the real time implementation of GPS/INS integration using a hybrid Adaptive Neuro Fuzzy Inference System (ANFIS) is proposed. The proposed system is trained during the availability of GPS signal to map the error between the GPS and the INS. Then it will be used to predict the error of the INS position components during GPS signal blockage. The data from GPS and INS are used to build a structured knowledge base consisting of behavior of the INS in some special scenarios of vehicle motion. In the absence of the GPS information, the system will perform its task only with the data from INS and with the trained data provided by ANFIS. The system is evaluated while considering several intentionally introduced GPS outages for periods of 50 seconds, with the position accuracy mostly below 0.2m. The simulated results show the advantages of the proposed method of ANFIS techniques for INS/GPS integration.

**TI.13** P0517

**A Benchmarking Tool for MAV Visual Pose Estimation**

Gim Hee LEE, Markus ACHTELIK, Friedrich FRAUNDORFER, Marc POLLEFEYS, Roland SIEGWART

ETH Zurich

The large collections of datasets for researchers working on the Simultaneous Localization and Mapping problem are mostly collected from sensors such as wheel encoders and laser range finders mounted on ground robots. The recent growing interest in doing visual pose estimation with cameras mounted on micro-aerial vehicles however has made these datasets less useful. In this paper, we describe our work in creating new datasets collected from a sensor suite mounted on a quadrotor platform. Our sensor suite includes a forward looking camera, a downward looking camera, an inertial measurement unit and a Vicon system for groundtruth. We propose the use our datasets as benchmarking tools for future works on visual pose estimation for micro-aerial vehicles. We also show examples of how the datasets could be used for benchmarking visual pose estimation algorithms.

**TI.14** P0610

**Mathematical Formulation of RFID Tag Floor based Localization and Performance Analysis for Tag Placement**

Youngsu PARK, Je Won LEE, Daehyun KIM, Jae Jin JEONG, Sang-woo KIM

Pohang University of Science and Technology

A radio-frequency identification (RFID) tag floor based localization is recently proposed indoor mobile robot localization method that utilizes super-distributed RFID tag infrastructure (SDRT) installed on a working area. An RFID tag floor localization (RTFL) method is easy to scale up the working area and the number of robots and is reliable in the position estimation. There have been several researches for practical applications of the RTFL, however, the investigation on performance and properties of the localization method is still insufficient. This paper propose a mathematical formulations of the RTFL and its performance index based on an RFID position estimation error variance. This paper also presents simulation results of the RTFL performances and analysis. These results can be used for optimal installation of the RFID tag floor.

**TI.15** P0682

**Ad-hoc Swarm Robotics Optimization in Grid Based Navigation**

Siddarth JAIN, Manish SAWLANI, Vijay Kumar CHANDWANI

Medi-Caps Institute of Technology and Management

A technology to identify a correct remote object and to carry it back to a base camp has become an important utility form, in the military for identifying improvised explosive devices (IEDs) and for space scientists to collect samples from mars. Multi-robot systems can accomplish tasks that would be impossible for a single robot to achieve. Developing multi-agent systems with self interested agents with a large behavioural repertoire is a great challenge. In this paper, we combine collaborative agent behaviour to deal with these vital issues. An ad-hoc design approach for swarm robotics optimization in grid based navigation is presented. Implementation of low power CC2500 wireless communication chip is done to accomplish multi-robot communication. Primitive behaviors called real-time grid search, move-to-goal, avoid-static-obstacle, avoid-robot behaviors are introduced for the path planning of multi-robot. The system is based on Real-time Grid Searching and Collision free Path Tracing & Retracing algorithm. A randomly placed remote object in the grid is identified and is carried to the base station with the effective coordination of the multi-robot system.

**TI.16** P0690

**Map Based Indoor Robot Navigation and Localization using Laser Range Finder**

Shung Han CHO, Sangjin HONG

Stony Brook University

This paper presents a map based robot navigation and localization algorithm using laser range finder for indoor environments. A navigation path is given by the sequence of grids and global map information is represented by the list of vertexes. The grid based navigation facilities path planning as well as complements localization with priori information of the grid sequence. The pattern of vertexes is represented by distance, adjacency, and slant among them for the comparison between map information
and range data. A mobile robot is globally localized by finding the matched pattern between the set of vertexes from the map and the set of vertexes from the range data. The proposed method is verified with actual range data from laser range finder.

**TI.17**  **P0782**

**Improved Genetic Algorithms Based Optimum Path Planning for Mobile Robot**

Chin Yun SOH, *Ganapathy VELAPPA, Ooi Chong LIM*

Monash University, Sunway Campus

*University of Malaya*

Improved genetic algorithms incorporate other techniques, methods or algorithms to optimize the performance of genetic algorithm. In this paper, improved genetic algorithms of optimum path planning for mobile robot navigation are proposed. An Obstacle Avoidance Algorithm (OAA) and a Distinguish Algorithm (DA) are introduced to generate the initial population in order to improve the path planning efficiency to select only the feasible paths during the evolution of genetic algorithm. Domain heuristic knowledge based crossover, mutation, refinement and deletion operators are specifically designed to fit path planning for mobile robots. Proposed genetic algorithms feature unique, simple path representations, and simple but effective evaluation methods. Simulation studies and real time implementations are carried out to verify and validate the effectiveness of the proposed algorithms.

**TI.18**  **P0851**

**Attitude Determination of Large Non-cooperative Spacecrafts in Final Approach**

Xuehai GAO, Bin LIANG, Wenfu XU

Harbin Institute of Technology

Due to failure of mechanisms to deploy, some large communication satellites lost their ability and resulted in huge economic cost. A space robotic system is expected to perform the on-orbit repairing mission. It is a tremendous challenge to navigate a space robot in final approach since the targets are generally non-cooperative. Rectangle features, which are common in the configuration of a satellite, can be chosen as the recognized objects. However, these characters are very large. Limited by the FOV (field of view), a monocular camera can not supply enough information of the rectangles. In this paper, a method based on monocular camera is proposed to determine the attitude of a large non-cooperative target using a partial rectangle. Firstly, the relationship of a rectangle and circular points by camera is derived and fused. Secondly, the attitude measurement algorithm is acquired from the constraint and a virtual rectangle is reconstructed. Lastly, the algorithm is verified by mathematic simulations which are very close to reality. The results show the validity and flexibility of the proposed method.

**TI.19**  **P0413**

**Modelling and Simulation of a Multi-fingered Robotic Hand for Grasping Tasks**

Juan Antonio CORRALES, Carlos A JARA, Fernando TORRES

University of Alicante

This paper develops the kinematic, dynamic and contact models of a three-fingered robotic hand (BarrettHand) in order to obtain a complete description of the system which is required for manipulation tasks. These models do not only take into account the mechanical coupling and the breakaway mechanism of the under-actuated robotic hand but they also obtain the force transmission from the hand to objects, which are represented as triangle meshes. The developed models have been implemented on a software simulator based on the Easy Java Simulations platform. Several experiments have been performed in order to verify the accuracy of the proposed models with regard to the real physical system.

**TI.20**  **P0512**

**New Hand Posture Classification Strategy for Finding Kinematically-Feasible Precision Grasps**

Peerapong THONNAGITH, Attawith SUDSANG

Chulalongkorn University

We present new strategy for finding kinematically-feasible precision grasps for particular robot hand. By collecting samples of hand posture and classifying them into multi level-of-detail of posture information for each hand configuration, we can efficiently search for valid hand postures given a set of contact points within reasonable processing time. The approach for creating hand posture database can be also applied to any kind of robot hands as long as the kinematic specification of those hands are provided.

**TI.21**  **P0943**

**Study on the Structure and Control of a Dexterous Hand**

Hao LIU, Tao WANG, Wei FAN, Tong ZHAO

Beijing Institute of Technology

A new dexterous hand is designed and produced. The shape and structure of the dexterous hand is described, focused on analyzing the layout of tendons and the optimization of the joint radius. Furthermore, a single finger is controlled by Fuzz-PID with model compensation and the good control precision is achieved. Through the study on the single finger control, the master-slave control of the dextrous hand is realized simulating the movement of human hand with a cyber-glove.

**TI.22**  **P0537**

**Coordinated Control of the Power Compensation Equipments Located in Local Substations of the District Unit Power System**

Sang-Deok LEE, Ji-Ho PARK, Young-Sik BAEK
Kyungpook National University

Decreasing stability of power system by voltage instability makes that all power system face with serious problems of stability. That is attributable to the difficulty of controlling the power system. So it is necessary to keep the voltage of load bus in range of the limited level to supply high quality of electric power. Therefore we describe and suggest on this paper that a plan for coordination control between UPFC(Unified Power Flow Controller), Shunt elements(Shunt capacitor & Shunt reactor) and ULTC(Under Load Tap Changer) among compensators and also describe the method to keep or control the voltage of power system in allowable ranges.

TI.23 P0306
Local Image Feature Matching for Object Recognition
Oleg O SUSHKOV, Claude SAMMUT
The University of New South Wales

We present a method for matching image local features, specifically SIFT features, to a database of learned object features for the purpose of object recognition and localisation. Our approach differs from existing methods by taking into account the geometric consistency of matched features concurrently with their description vector similarity. As a result we do not need to over-constrain the description vector matching criteria (description vectors of matching features do not need to be nearest neighbours). The outcome of our approach is a greater number of feature matches between a scene image and a database image, as well an improvement in matching speed under certain circumstances.

TI.24 P0437
Human Face Detection using Color Spaces and Region Property Measures
Vijayanand R, *BALAKRISHNAN G
J.J. College of Engineering and Technology
*Indra Ganesan College of Engineering

Face detection is the first step in automated face recognition and the important cue to detect the human face is skin color. This proposed paper consists of two steps, the first step is to detect the more skinned region by the fusion of RGB, YCbCr skin color region and CIEL*a*b skin labeled image using HillClimbing segmentation with K-Means clustering. This step helps to simplify and improves the detection of human faces, since nonskin regions are eliminated. The second step is to locate the faces in a fused image by Region property measures. The proposed method has been tested on various real images and its performance is found to be quite satisfactory.

TI.25 P0609
An Improved Algorithm for Segmenting and Recognizing Connected Handwritten Characters
Xiaoyu ZHAO, Zheru CHI, Dagan FENG
The Hong Kong Polytechnic University

In this paper, an improved algorithm is proposed for the segmentation and recognition of handwritten character strings. In the method, a gradient descent mechanism is used to weigh the distance measure in applying KNN for segmenting/recognizing connected characters (numerals and Chinese characters) in the left-to-right scanning direction. In recognizing connected characters, a high quality segmentation technique is essential. Conventional approaches attempt to separate the string into individual characters without recognition and apply a recognition algorithm onto each isolated character, resulting improper segmentation and poor recognition results in many situations. Our proposed algorithm simulates the human beings's process in recognizing connected character strings where segmentation and recognition is mingled with each other. Experimental results on 1959 character strings from the USPS database of postal envelopes show that the algorithm works robustly and efficiently.

TI.26 P0790
Automatic Traffic Monitoring using Neural Networks from Satellite Images
Mehrad ESLAMI, *Karim FAEZ
Azad University of Qazvin
*Amirkabir University of Technology, Tehran

Considering the widespread problems of road transport, approach of the paper is a system to automatically control the roads by using images from satellite in night and day. Although no coherent system with appropriate performance has been yet introduced to achieve this goal, some methods has been proposed to estimate the road or recognize objects on the road, which have been more based on thresholding and color-based object recognition; and therefore, their efficiencies have direct relationship and a lot of dependence with the type of input image. In this paper, a complete and coherent system has been introduced to detect traffic by using satellite images, in which a special attention is paid to extraction of the road and vehicles on the road by using image processing and machine learning (including feature extraction, morphology methods, and algorithms of labeling); and rate of road traffic is estimated by using the obtained results and by using neuro-fuzzy network. Previous works has been introduced in the paper; and finally, the obtained results have been compared with the past appropriate methods. Higher accuracy and less dependence on the input image is among the results that have been explained in detail in last section of the paper in which and results for various images from satellite show an accuracy of about 85%.

TI.27 P0832
Sequential Monte-Carlo Estimation Based Road Region Segmentation Considering Perspective Projection
Contour extraction method, which will benefit to the proposed method in the sense that newly considered perspective projection of road plane by camera. The proposed approach is examined on real image sequences, and compared with the first one.

TI.28 P0845
An Efficient Edge and Corner Detector
Song YANG, Siew Kei LAM, Thambipillai SRIKANTHAN
Nanyang Technological University

This paper describes an efficient method for image edge and corner detection. Edges are detected before extracting corner points so that the background or noise of the image can be effectively removed. We propose an edge detector that utilizes edge features to localize the edge points. The corner points of an image are then identified by evaluating the degree of turning in the edge direction. The proposed edge and corner detection utilizes low complexity computations. Based on the experiments considered, it can be observed that the proposed edge and corner detector achieves more accurate results than several other well known algorithms. In addition, the proposed method performs faster than most of the other well known algorithms.

TI.29 P1028
An Initial Edge Point Selection and Segmental Contour Following for Object Contour Extraction
Roy Chaoming HSU, Ping-Wen KAO, Wei-Jie LAI, Cheng-Ting LIU
National Chiayi University

Image segmentation is a technique used to segment region of interest (ROI) in the image for further image processing applications. Contour extraction is one of the most important image segmentation methods. In this paper, a contour extraction method is proposed, which consist of two stages. The first stage is automatic initial edge point selection (IEPS), and the second stage is segmental contour following (SCT) based on the edge points obtained at the first stage. Experiment result shows that, in comparing with other existing methods, more accurate contour can be obtained with low computational complexity using the proposed object contour extraction method, which will benefit to applications of industrial inspection or machine vision with low-level processor.

TI.30 P1130
Advance in Triangular Mesh Simplification Study
Mingyi HE, Long LI
Northwestern Polytechnical University

With the development of modern 3D acquisition facilities and tools, large mesh models with high-precision for the representation of complex geometric objects becomes feasible. However, many considerable difficulties have emerged in these huge mesh models, such as the storage capacity and rendering speed of computers. Triangular mesh, which is one of the most popular polygonal meshes, plays an important role in mesh simplification field. Many different methods and algorithms have been put forward to the research of triangular mesh simplification in the past few years. In this paper, triangular mesh simplification algorithms and their corresponding improved algorithms are overviewed. In addition, some recent achievements of triangular mesh simplification in the author’s laboratory (IAP) are presented. Finally, future development and prospects in this area are also discussed and outlined, respectively.

TI.31 P1001
Facial Part Displacement Effect on Template-based Gender and Ethnicity Classification
Fahimeh SAEI MANESH, Mohammad GHAHRAMANI, Yap-Peng TAN
Nanyang Technological University

Visual information such as gender, age and ethnicity play critical roles in human identification. Most of gender and ethnicity recognition research works use the full face considering equal discriminant capability to different face parts. In this paper, we improve the gender and ethnicity recognition, by employing the optimum decision making rule on the confidence level of automatically separated face regions using the modified Golden ratio mask. Faces are preprocessed with multiple base point photometric normalization to prevent the displacement of facial parts in the noted mask, due to different facial parts’ distances of the people. SVM is employed as the classifier on the extracted Gabor features of each patch to get its confidence level. The final classification results are obtained based on the output of each patch decision using the optimum decision making rule. Finally, using the most accurate normalization approach for each patch, we could achieve 94% and 98% for gender and ethnicity respectively on a dataset composed of FERET and PEAL frontal face images.

TI.32 P0407
Fluid Dynamics Analysis of Contrast Media in Left Ventriculography
Lay-Lan LEE, *Gwo-Chung TSAI, **Chien-Wei LIU
Tzu Chi University
*National I-Lan University
St. Mary's College

A contrast media was injected into the left ventricle through a pig-tail catheter and imaged with X-ray angiography to observe pathological changes of the left ventricle. The sidehole design of the cardiac pigtail catheter affects scope visualization, and limited research related to this subject has been performed. In this study, a computational fluid dynamics method was applied to observe the distribution of Renografin-76 contrast media using five and eight sideholes cardiac catheters. The results showed that the eight sideholes catheter had a more rapid rate of contrast media delivery compared to the five sideholes catheter. In conclusion, a larger area of the left ventricle was observed through the eight sideholes catheter compared to the five sideholes catheter.

TI.33  P0580

A Patch-based Spatiotemporal Phase Unwrapping Method for Phase Contrast MRI using Graph Cuts

Wenyu XIE, Ying SUN, Sim Heng ONG
National University of Singapore

Phase unwrapping is an important and challenging problem in phase contrast magnetic resonance imaging (PC-MRI). In this paper, we propose a new algorithm for phase unwrapping based on graph cuts. Our algorithm takes a patch-based approach which has the advantages of simplicity and robustness to phase noise. To make use of temporal information from the neighboring frames as well as spatial information from the current frame, the energy function is designed to combine both spatial and temporal constraints. The proposed method has been tested with real PC-MRI data. Experimental results demonstrate that our algorithm is capable of unwrapping images with severe phase wrapping, and that it outperforms other existing popular phase unwrapping algorithms both qualitatively and quantitatively.

Session FA1

Date:  Friday, 10 December 2010
Time:  1000 - 1200
Venue: Ball Room

Nonlinear Systems

Chairs:  Bill GOODWINE
         University of Notre Dame
          Maryam DEHGhani
          Shiraz University

FA1.1  P0147  1000 - 1020

Robust Stabilization using Time-scaling and Lyapunov Redesign: The Ball-beam System

R Maruthi T, Arun D MAHINDRAKAR
Indian Institute of Technology, Madras

This paper proposes a nonlinear stabilizing controller for a ball on an end-actuated beam system, which is robust to an uncertainty in the mass of the ball. To this end, the dynamics is time-scaled into two subsystems termed as the 'Outer-Loop' and the 'Inner-Loop' dynamics. An Outer-Loop controller generates a reference trajectory for the beam's pitch angle, which if faithfully followed, would result in the stabilization of all states of the system. A robust Inner-Loop controller is synthesized using the Lyapunov redesign technique, which forces the actual pitch angle to stabilize to the trajectory of the Outer-Loop controller. It is shown that the effects of the uncertainty in the mass of the ball are eliminated by the Inner-Loop controller. The uncertainty tolerance limit of this robust controller is also characterized through a necessary condition. Experiments validate the effectiveness of this strategy in stabilizing the system.

FA1.2  P1029  1020 - 1040

Lyapunov Based $H_{\infty}$ Controller Design in Multimachine Power Systems

Maryam DEHGhani, *Seyyed Kamaleddin NIKRAVESH
Shiraz University
*Amirkabir University of Technology, Tehran

In this paper, nonlinear $H_{\infty}$ controller problem in large-scale systems is investigated. The paper needs to find an energy function which satisfies the Hamilton Jacobi inequality. The energy function of the whole large scale system is considered to be the sum of the energy functions of the isolated subsystems. When the inequality is solved, a decentralized state feedback controller for each subsystem is obtained. The controller can be implemented locally in each subsystem. The method is tested on a sample multi-machine power system model. Simulation results show the effectiveness, robustness and good performance of the proposed controller.
Multi Objective Evolutionary Programming to Solve Environmental Economic Dispatch Problem

Bo-Yang QU, Suganathan PONNUTHURAI
NAGARATNAM, *V. R. PANDI, *B. K. PANIGRAHI
Nanyang Technological University
*Indian Institute of Technology, Delhi

In this paper, the nonlinear constrained multi-objective environmental economic dispatch (EED) problem is solved using fast multi-objective evolutionary programming (FMOEP). Due to the global warming by fossil fuel, environmental concern becomes more and more important in recent years. The purpose of multi-objective optimization algorithm is minimizing all the different objectives simultaneously and finds the best tradeoff solution for this environmental/economic dispatch problem. In order to evaluate the performance of FMOEP on EED problems, the standard IEEE 30-bus six-generator test system is studied. The performance is compared against NSGAII and a number of results reported in literature. The results show that the FMOEP is effective in solving EED problems.

Adaptive Control of Singular Nonlinear Systems with Convex/Concave Parametrization

Qingxiang FANG, Feilong CAO
China Jiliang University

This note is concerned with the model reference adaptive tracking problem of singular nonlinear systems with nonlinear parametrization where the nonlinearity in the parameters is convex or concave. Applying the standard coordinate transformation to the singular system to yield a reduced-order normal system, we convert the model reference adaptive tracking problem of singular system into the model reference adaptive tracking problem of normal system and obtain solvability conditions. The proposed controller ensures that the overall adaptive system has globally bounded solutions and achieves tracking to within a desired precision.

Multi-layer Moving-window Hierarchical Neural Network for Modeling of High-density Polyethylene Cascade Reaction Process

Yuan XU, Qunxiong ZHU
Beijing University of Chemical Technology

With the growing scale of industry production, process modeling has been paid more and more attention, which could effectively explore the dynamics of the process and provide guidelines to production operation. High-density polyethylene (HDPE) cascade reaction process is such a complex and nonlinear industry process. To enhance the performance of process modeling, a multi-layer moving-window hierarchical neural network (MMHNN) is proposed, which is developed with the incorporation of multi-layer moving-window concept and hierarchical neural network (HNN). Multi-layer moving-window is used to ensure the continuity and time-variation, HNN is used for input compression and model prediction, which can effectively capture the changing process dynamics, reduce the data dimension and reveal the nonlinear relationship between process variables and final output. For comparison, single-layer moving-window HNN (SMHNN) and HNN are also established for the process modeling. Through the actual application in HDPE cascade reaction process of a chemical plant, the prediction results show that MMHNN is obviously better than SMHNN and HNN with higher accuracy, thus exploits a new and efficient way to simulate and guide the industry process.
This work provides a convergence analysis for the estimate error covariance of Kalman filtering based on quantized measurement innovations (QIKF). By taking the quantization errors as random perturbations in observation system, an equivalent state-observation system is given. Accordingly, the quantitative Kalman filter for the original system is equivalent to a Kalman-like filtering for the equivalent state-observation system. In this performance analysis framework, the true covariance matrix of estimating error is strictly analyzed without Gaussian assumption on predicted distribution. A necessary and sufficient condition for the stability of the QIKF is obtained. Then, the relationship between the standard Kalman filtering and the QIKF for the original system is discussed. Finally, the validity of these results are demonstrated by numerical simulations.

Security Enhancement with Optimal QoS using ECDH for Converged 3G-WLAN System

Shankar RAMALINGAM, *Timothy RAJKUMAR K, *Dananjayan PERUMAL
Sri Manakula Vinayagar Engineering College, Pondicherry
*Pondicherry Engineering College

The convergence of third generation (3G) wide area wireless network and wireless local area network (WLAN) offers characteristics that complement each other perfectly. To provide secure 3G-WLAN convergence, extensible authentication protocol-authentication and key agreement (EAPAKA) protocol, that has got many risk, is used. This paper elaborate risks in using EAP-AKA for 3G-WLAN convergence, proposes an authentication and key agreement protocol that combines elliptic curve Diffie-Hellman (ECDH) with symmetric key cryptosystem. The proposed protocol when analysed using simulation tool shows that it not only overcomes the risk, it ensures optimal quality of service (QoS) because of its less delay for authentication compared to EAP-AKA.
network based on the locust vision system generated the signal for avoiding the collision of the object. It was clarified from the simulation results that the proposed simple circuit and network can detect the time to collision, the size and the velocity of the approaching object.

In this paper, a new hybrid incremental learning algorithm for Bayesian network structures is proposed. It develops a polynomial-time constraint-based technique to build up a candidate parents set for each domain variable, and a hill climbing search procedure is then employed to refine the current network structure under the guidance of those candidate parents sets. Our algorithm always offers considerable computational complexity savings while obtaining better model accuracy compared to existing incremental algorithms when dealing with complex real-world problems. The more complex the real-world problems are, the more significant the advantage our algorithm keeps is.

Session FA3 - Invited Session
Date: Friday, 10 December 2010
Time: 1000 - 1200
Venue: Kingfisher

Robotics in Unstructured Environments
Chairs: XiaoQi CHEN, University of Canterbury
        De XU, Chinese Academy of Sciences

FA3.1 P0308 1000 - 1020
Wavelets/Multiwavelets Bases and Correspondence Estimation Problem: An Analytic Study
Asim BHATTI, Saeid NAHAVANDI, Mohammed HOSSNY
Deakin University
Correspondence estimation is one of the most active research areas in the field of computer vision and number of techniques has been proposed, possessing both advantages and shortcomings. Among the techniques reported, multiresolution analysis based stereo correspondence estimation has gained lot of research focus in recent years. Although, the most widely employed medium for multiresolution analysis is wavelets and multiwavelets bases, however, relatively little work has been reported in this context. In this work we have tried to address some of the issues regarding the work done in this domain and the inherited shortcomings. In the light of these shortcomings, we propose a new technique to overcome some of the flaws that could have significantly impact on the algorithm performance and has not been addressed in the earlier propositions. Proposed algorithm uses multiresolution analysis enforced with wavelets/multiwavelets transform modulus maxima to establish correspondences between the stereo pair of images. Variety of wavelets and multiwavelets bases, possessing distinct properties such as orthogonality, approximation order, short support and shape are employed to analyse their effect on the performance of correspondence estimation. The idea is to provide knowledge base to understand and establish relationships between wavelets and multiwavelets properties and their effect on the quality of stereo correspondence estimation.

FA3.2 P0313 1020 - 1040
Control System Design for a 5-DOF Table Tennis Robot
Ping YANG, De XU, Huawei WANG, Zhengtao ZHANG
Chinese Academy of Sciences
A visual control system is designed for a table tennis robot with five degrees of Freedom (DOFs). It consists of four parts such as ball sensing, trajectory predicting, motion planning, and motion control. A high-velocity stereo vision system with parallel architecture is developed to sense the motions of
table tennis ball. The striking parameters including position, velocity, and time are predicted according to the predicted trajectory of the ball based on several measured positions. The motion computer receives the predicted striking parameters and performs motion planning for the robot. A motion control card embedded in the motion computer receives the planning results and controls the motions of the robot via the servo drivers for X and Y axes. A microprocessor is designed to produce pulses to control the motions of the rest three axes via the drivers. Experiments are well conducted to verify the effectiveness of the developed robot and control system.

FA3.3 P0360 1040 - 1100
Rocket Roll Dynamics and Disturbance - Minimal Modelling and System Identification
Christopher E HANN, Malcolm SNOWDON, Avinash RAO, Robert TANG, Agnetha KOREVAAR, Greg SKINNER, Alex KEALL, et al
University of Canterbury

The roll dynamics of a 5kg, 1.3 m high sounding rocket are analyzed in a vertical wind tunnel. Significant turbulence in the tunnel makes the system identification of the effective inertia, damping and asymmetry with respect to roll challenging. A novel method is developed which decouples the disturbance from the rocket frame’s intrinsic roll dynamics and allows accurate prediction of roll rate and angle. The parameter identification method is integral-based, and treats wind disturbances as equivalent to a movement in the actuator fins. The method is robust, requires minimal computation, and gave a realistic disturbance distribution reflecting the randomness of the turbulent wind flow. The mean absolute roll rate of the rocket frame observed in experiments was 16.4 degrees/s and the model predicted the roll rate with a median error of 0.51 degrees/s with a 90th percentile of 1.25 degrees/s. The roll angle (measured by an encoder), was tracked by the model with a median absolute error of 0.25 degrees and a 90th percentile of 0.50 degrees. These results prove the concept of this minimal modeling approach which will be extended to pitch and yaw dynamics in the future.

FA3.4 P0492 1100 - 1120
Spline-Interpolation Based PVT Algorithm and Application in a Bionic Cockroach Robot
Haosong YUE, Weihai CHEN, *Wenjie CHEN, Xingming WU
Beijing University of Aeronautics and Astronautics *Singapore Institute of Manufacturing Technology

To solve the problem that the final velocity curve will be unsmoothed if the PVT(Position Velocity Time) nodes velocities are determined improperly when using PVT control algorithm, based on analyzing the general principle of spline interpolation and PVT motion control, this paper presents a triple spline interpolation based PVT algorithm, which ensures the smoothness of the velocity curve. The velocity of each node is firstly calculated via spline interpolation, and then the final trace control curve is achieved by using PVT method to these points. The proposed algorithm is applied to the kinematics control of a cockroach robot. The structure and forward/inverse kinematics model of the cockroach robot is expounded. Finally, the reliability of the proposed algorithm is verified by the contrast simulation and experiment of a single leg of the cockroach robot with one of the existing algorithms. The results show that the proposed approach can be readily used for motion controls.

FA3.5 P0528 1120 - 1140
Towards Autonomous Image Fusion
Mohammed HOSSNY, Saeid NAHAVANDI, Doug CREIGHTON, Asim BHATTI
Deakin University

Mobile robots are providing great assistance operating in hazardous environments such as nuclear cores, battlefields, natural disasters, and even at the nano-level of human cells. These robots are usually equipped with a wide variety of sensors in order to collect data and guide their navigation. Whether a single robot operating all sensors or a swarm of cooperating robots operating their special sensors, the captured data can be too large to be transferred across limited resources (e.g. bandwidth, battery, processing, and response time) in hazardous environments. Therefore, local computations have to be carried out on board the swarming robots to assess the worthiness of captured data and the capacity of fused information in a certain spatial dimension as well as selection of proper combination of fusion algorithms and metrics. This paper introduces to the concepts of Type-I and Type-II fusion errors, fusion capacity, and fusion worthiness. These concepts together form the ladder leading to autonomous fusion systems.

FA3.6 P0736 1140 - 1200
A Flexure-Based 4-DOF Coaxial Alignment System: Design and Application
Wenjie CHEN, Wei LIN, Guilin YANG
Singapore Institute of Manufacturing Technology

This paper presents the design of a novel 4-DOF (x-y-\text{Ex}-\text{Ey}) flexure-based system used for coaxial alignment. The movable head (a rigid rod) of the system is suspended with two monolithic flexural mechanisms constructed with leaf flexures. To achieve the required x-y-\text{Ex}-\text{Ey} motion, the leaf-type flexures are specially arranged such that the configuration is compliant in the specified axes but stiff in other axes. The leaf flexures are initially designed based on the linear models of the flexible beam deflection and then improved through FEA simulations. A system prototype was built with the flexural mechanisms. It demonstrates superior motion performances in the x and y axes as well as the angular axes. The prototype has been successfully applied in the coaxial alignment of the capillary machining.
**Session FA4**

**Date:** Friday, 10 December 2010  
**Time:** 1000 - 1200  
**Venue:** Nightingale

**Intelligent Automation**  
**Chairs:** Manish M PATIL  
MAE College of Engineering, Pune  
Yongduan SONG  
Beijing Jiaotong University

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**FA4.1 P0624 1000 - 1020**

**A Novel SVM Based Approach for Noisy Data Elimination**  
Narendra S CHAUDHARI, *Aruna TIWARI, *Jaya THOMAS  
Indian Institute of Technology, Indore  
*SGS Institute of Technology and Science, Indore

In this paper we propose a novel Support Vector Machine(SVM) based approach for noisy data removal from datasets. It is observed that the instability present in the dataset greatly affects the overall performance of the any classifier. Hence, we propose a methodology for removal of such instabilities. In the proposed approach, we proceed by determining the clusters formed using support equilibrium points. Then analyzing, each cluster and remove the noisy data using the accuracy factor. Our approach, provide an important feature for reducing the training time and reducing the misclassification test error. The methodology if adopted for classifiers before the training phase will enhance the efficiency of the system. The approach is being tested on benchmark dataset, and it is observed that the efficiency of classifier increased by 15-20%.

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**FA4.2 P0714 1020 - 1040**

**Novel Simulated Annealing Algorithm in order to Optimal Adjustment of Digital PID Controller**  
Mohammad DASHTI J, *Kambiz SHOJAEE G, **S Mohammad H SEYEDKASHI, ***Mojtaba Behnam  
TAGHADOSI  
Sadjad Institute of Higher Education  
*University of Tehran  
**Tarbiat Modares University  
***Politecnico di Torino

This article presents a method for optimal tuning of PID controllers by using simulated annealing optimization algorithm and tries to increase speed and decrease errors in PID controller by adding intelligent techniques to the basic algorithm. The objective of this paper is to reduce errors and minimize IAE, ITAE, ISE and ITSE assessment criteria to be able to obtain a unique step response of the system in its best output tuning by PID controller. This system is not limited to a particular process and is applicable for all plants. In this paper, SMT motion system with constant load torque is used as disturbance for execution of PID controller with this proposed method.

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**FA4.3 P0828 1040 - 1100**

**Multi-criteria Optimization of the Parallel Mechanism with Actuators Located Outside Working Space**  
Minh Thanh NGUYEN, *Victor GLAZUNOV, Cong Tuan TRAN, Xuan Vinh NGUYEN  
Ho Chi Minh City University of Transport  
*Russian Academy of Sciences

This paper addresses the development of automation of designing a parallel mechanism with actuators located outside the working space which in purpose to achieve an increase their working volume and load capacity. It is known that a parallel mechanism with singularity configurations can gain one or more degrees of freedom and become uncontrollable. That is it might not reproduce a stable motion under a prescribed trajectory. However, it is proved that there is possible passing through the singular zones. Therefore, the utility of using the approach determination of the twists inside singularity to rely on the theory of screws is considered. Besides, the method is used to propose optimal design of the parallel mechanisms, based on the multi-criteria optimization obtaining the Pareto set.

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**FA4.4 P0869 1100 - 1120**

**Dealing with Nonlinear and Uncertain Nonlinear Resistances in Train Control via Adaptive Approach**  
Qi SONG, Yongduan SONG  
Beijing Jiaotong University

Resistive forces such as mechanical frictions and aerodynamic drags are inevitable in high speed train during its operation. This paper investigates the problem of adaptive compensation of such uncertain resistive forces in train systems to achieve high precision speed and position tracking. A control scheme is developed via adaptive backstepping approach to address not only the traction and braking dynamics ignored in most existing methods, but also the uncertain resistive forces arisen from varying operation conditions. Both theoretical and numerical simulation confirms that the resultant control algorithms are able to achieve high precision train position and speed tracking.

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**FA4.5 P0664 1120 - 1140**

**Fuzzy Feeder Models for Distribution System Calculations**  
Shyi-Wen WANG  
Chienkuo Technology University

Using fuzzy set theory, this study presents three novel distribution fuzzy feeder models to simplify complicated distribution system calculations. These fuzzy models are formulated using lumped distribution transformer(s) and lumped load(s) to
represent non-uniformly distributed loads, which vary by time and type of day and relate to voltage, along a feeder. These equivalent models are developed to accurately simulate first, the total series voltage drop at the end of given feeder, and then the total copper and core losses. Finally a hybrid model is developed to simulate both voltage drop and feeder losses accurately. A physical feeder is used as a sample feeder to demonstrate the correctness of these proposed fuzzy feeder models.

FA4.6  P0906  1140 - 1200
Novel Integrated Development Environment for Implementing PLC on FPGA by Converting Ladder Diagram to Synthesizable VHDL Code
Shaila SUBBARAMAN, *Manish M PATIL, **Prashant S NILKUND
Walchand College of Engineering, Sangli
*MAE College of Engineering, Pune
**Laboratory for Applied Research in Electronics, Mumbai

Programmable logic controllers (PLCs) are the universally accepted automation components in industrial control. IEC61131-3 standard was developed to unify textual and graphical ways of describing the control specification for PLCs; ladder diagram being one such control specifications. However, PLCs available in the market as on today are vendor specific and replacement of PLC of one vendor in a process equipment by PLC of another vendor is not possible due to lack of standardization among EDA tools from PLC vendors. Secondly, heart of PLCs is a sequential processor which cannot execute parallel rungs of ladder diagram concurrently. Perhaps this aspect did not pose any problem so far due to large response times associated with industrial processes. However with introduction of high speed MEMS sensors along with increased control complexity, the need for high speed PLCs has been spelt out. Further, the safety features of control system are now expected to be integral part of ladder control specification. Field Programmable Gate Arrays (FPGAs) have better portability support, ability to support implementation of concurrent logic and security aspects. They have been mentioned in the literature as prospective programmable devices to implement control logic of PLCs. However, utilization of FPGAs for implementing control specification demands development of integrated environment to convert ladder logic as per IEC61131-3 to HDL. This HDL specification further can be ported to any of the standard FPGA development environments. It is seen through literature that not enough efforts have been focused on developing such integrated environment. This paper focuses on the details of such environment being developed by authors to convert IEC-61131-3 control specification standard to VHDL for direct synthesis.

Session FA5 - Invited Session
Date: Friday, 10 December 2010
Time: 1000 - 1200
Venue: Pelican

Autonomy of Vehicular Systems II
Chairs: Philippe MARTINET
        Clermont Université
        Han WANG
        Nanyang Technological University

FA5.1  P1153  1000 - 1020
A GA based SLAM with Range Sensors only
Han WANG, Yi YAN, Danwei WANG
Nanyang Technological University

This paper describes a GA approach for solving the SLAM problem. We treat the local scan from laser sensor as an image pattern. Two subsequent scans were matched to find the robot's ego motion. This motion is used as updates for robot's global position estimation in the map. A virtual scan is obtained from the map in the robot's current position. This virtual scan is then matched with the current laser scan to update robot's location in the map. The innovation in this paper is the matching algorithm to determine the relative location of two patterns: (1) two successive scans and (2) current scan with virtual scans taken from the map. The matching algorithm is to find the optimal location of one pattern to the other, namely (dx,dy,dθ) (two for translation and one for rotation). This is reduced to a three-dimensional search problem. The GA we developed can achieve high accuracy with fast computational time. Experiments are performed under simulated and real data. The performance obtained outperforms ICP.

FA5.2  P1120  1020 - 1040
Urban Vehicle Platoon using Monocular Vision: Scale Factor Estimation
Pierre AVANZINI, Benoit THUILOT, Philippe MARTINET
Clermont Université

Environment, sustainable development as well as new transportation service emergence in urban areas are major concerns. Consequently, studies are currently intended to automate electric vehicles designed for applications in free access. An additional functionality that appears very attractive is vehicle platooning. In order to avoid oscillations within the fleet when completing this task, a global control strategy, supported by inter-vehicle communications, is investigated. Vehicle absolute localization is then needed and is here derived from monocular vision. These data are however expressed in a virtual vision world, slightly distorted with respect to the actual metric one. It has previously been shown that such a distortion can accurately be corrected on-line in different ways, considering telemetric or odometric data. These strategies have here been refined in
order to provide optimal corrections. A comparative study, supported by simulations and full-scale experiments, is reported to exhibit benefits and performances of proposed approaches.

**FA5.3 P1150 1040 - 1100**

**A Lidar Perception Scheme for Intelligent Vehicle Navigation**

Julien MORAS, V´eronique CHERFAQUI, Phillipe BONNIFAIT
Université de Technologie de Compi`egne

In urban environments, moving obstacles detection and free space determination are key issues for driving assistance systems or autonomous vehicles. This paper presents a lidar-based perception system able to do simultaneously mapping and moving obstacles detection. Nowadays, many lidars provide multi-layer and multi-echo measurements. A smart way to handle this multi-modality is to use grids projected on the road surface in both global and local frames. The global one generates the mapping and the local one is used to deal with moving objects. An approach based on both positive and negative accumulation has been developed to address the remnant problem of quickly moving obstacles. This method is also well suited for multi-layer and multi-echo sensors since it is able to handle efficiently the uncertainty that exists between the projected echoes. Experimental results obtained with an IBEO Alasca and an Applanix positioning system show the performance of such a perception strategy.

**FA5.4 P0523 1100 - 1120**

**Design of a Wheel-Propeller-Leg Integrated Amphibious Robot**

Jiancheng YU, Yuangui TANG, Xueqiang ZHANG, Chongjie LIU
Chinese Academy of Sciences

The operation capabilities of robot in the amphibious environments (such as shallow water fields, surf zones, and beaches) are critical for military and civilian. In this paper, we introduce a novel amphibious robot with wheel-propeller-leg integrated driving devices, developed by Shenyang Institute of Automation, which can realize both crawling locomotion on the ground and swimming locomotion in the water without changing its driving devices. This paper describes the design of the overall robot structure, the design of the novel driving devices, and the design of the embedded control system, respectively. All the driving devices of the robot are driven by independent motor, thus the amphibious robot can conveniently switch its locomotion modes according to the operational environments. The embedded control system is a distributed control system based on CAN bus, which makes it is easy to expend sensors and devices for the robot in the future. Finally, the hydrodynamic performances of the wheel-propeller device are analyzed by using CFX hydrodynamic calculation software, and some primary experiments have been done for verifying the fundamental locomotion functions of the robot.

**FA5.5 P0352 1120 - 1140**

**A MDL-Based Control Method for Tele-robotic Systems over Internet**

Northeastern University

*Chinese Academy of Sciences

A MDL-based control method for tele-robotic systems over internet is presented in this paper. Internet-based tele-robotic systems are characterized by the fact that the operator and the remote robotic system are connected by Internet. Since limited bandwidth, random time delay and other transmission problems deteriorate performance of tele-robotic systems severely, control strategies which can be used to settle transmission problems are expected. The obvious characteristic of the new method introduced in this paper is that control commands have a linguistic flavor, data transferred between operator and remote robot can be reduced accordingly. The framework presented in this paper has the potential of reducing operator’s working pressure and enhancing the performance of the system. Furthermore, the existing motion description language modal is expanded to deal with the packet loss and disorder problem. The main contribution of this paper is the development of a novel framework for tele-robotics and its implementation in a real tele-manipulator system.

**FA5.6 P0516 1140 - 1200**

**Development of a Tele-guidance System with Fuzzy-based Secondary Controller**

Manh Duong PHUNG, Thanh Van Thi NGUYEN, Cong Hoang QUACH, Quang Vinh TRAN
Vietnam National University, Hanoi

Dealing with the uncertainties of Internet characteristics is an important issue that needs being taken into account in developing Internet-based real-time systems. In this paper, we present our approach in applying fuzzy logic to develop back-up mechanisms for an Internet-based mobile robot to deal with unwanted network problems such as long delays or network interruptions. A tele-guidance application involving the remote control of a mobile robot via the Internet is set up as the context to verify the effectiveness and applicability of the proposed approach.
In recent years, 3D face recognition has become a popular solution to deal with the problem of pose-invariant face recognition. The majority of 3D face data are, however, actually 2.5D, which are sensitive to pose variations. This paper presents a novel Geodesic Texture Warping (GTW) solution for 2.5D pose-invariant face recognition. In this method, we use the geodesic distance computed on a 2.5D face scan to warp the texture of a rotated face to that of a frontal one to perform matching. A feasibility and effectiveness investigation for the proposed method is conducted using a wide range of experiments including samples with different face rotations. The encouraging experimental results demonstrate that the proposed method achieves much higher accuracy than the state-of-the-art method with a low computational cost.
Recognizing Face Profiles in the Presence of Hairs/glasses Interferences

Weiping CHEN, Yongsheng GAO
Griffith University

Facial profile provides a complementary structure of the face that is not present in frontal faces, which has been used in personal identification, face perception research and 3D face construction. In this paper, we present a novel local attributed string matching (LAStrM) approach to recognize face profiles in the presence of interferences. The conventional profile recognition algorithms heavily depend on the accuracy of the facial area cropping. However, in realistic scenarios the facial area may be difficult to localize due to interferences (e.g., glasses, hairstyles). The proposed approach is able to efficiently find the most discriminative local parts between face profiles addressing the recognition problem with interferences. Experimental results have shown that the proposed matching scheme is robust to interferences compared against several primary approaches using two profile image databases (Bern and FERET). It has potential capability for partially occluded shape classification.

Dense SIFT and Gabor Descriptors-Based Face Representation with Applications to Gender Recognition

Jian-Gang WANG, Jun LI, Chong Yee LEE, Wei Yun YAU
Institute for Infocomm Research

In this paper, a novel face representation in terms of dense local image descriptors is proposed. Scale Invariant Feature Transform (SIFT) and Gabor, two of the most popular local image descriptors, at dense grid pixels of a face image are used to represent the face. The efficiency of the representation has been investigated in gender recognition. There are four problems when applying the SIFT to facial gender recognition. (1) There may be only a few keypoints that can be found in a face image due to the missing texture and ill-illuminated faces. (2) The SIFT descriptors at the keypoints (we called it sparse SIFT) are distinctive whereas alternative descriptors at non-keypoints (e.g. grid) could cause negative impact on the accuracy. (3) Most of the existing methods employ SIFT descriptors matching in which relative larger image size is required in order that enough keypoints can be found to support the matching. (4) The matching is assumed that the faces are well registered. We provide solutions to the above difficulties in this paper and the problem of recognizing gender using the combination of SIFT descriptors and Gabor of face images is studied. The Gabor representations of the face images are fused with the dense SIFT at the feature-level to improve the accuracy. AdaBoost is adopted to select features and form a strong classifier. The experimental results on a large set of faces have shown that the proposed method can achieve high accuracies even for faces that are not aligned.

Session FA7

Date: Friday, 10 December 2010
Time: 1000 - 1140
Venue: Bluebird

Image/Video Analysis II

Chairs: Eam Khwang TEOH
Nanyang Technological University
Yongqiang YE
Nanjing University of Aeronautics and Astronautics

FA7.1 P0490 1000 - 1020
A Neural Network Model with Adaptive Structure for Image Annotation

Zenghai CHEN, Hong FU, Zheru CHI, Dagan FENG
The Hong Kong Polytechnic University

A neural network model with adaptive structure for image annotation is proposed in this paper. The adaptive structure enables the proposed model to utilize both global and regional visual features, as well as correlative information of annotated keywords for annotation. In order to achieve an approximate global optimum rather than a local optimum, both genetic algorithm and traditional back-propagation algorithm, are combined for model training. The neural network model is experimented on a synthetic image dataset with controllable parameters, which has not been used in previous image annotation experiments. Experimental results demonstrate the effectiveness of the proposed model.

FA7.2 P0769 1020 - 1040
Novel Gray-scale Watermarking Algorithm based on QFT

Chi ZHAO, Weijiang WANG, *Xiwei HUANG
Beijing Institute of Technology
*Nanyang Technological University

This paper proposes a novel algorithm of embedding gray-scale watermark image into an RGB host image based on the Quaternion Fourier Transform (QFT). The R, G, B color components are represented respectively by the three imaginary parts of a pure imaginary quaternion and the gray-scale watermark image is inserted into the real part of the carrier image which is transformed by the QFFT. By using the symmetrical characteristic of the real part, we achieve the insertion of the gray-scale watermark image without lose. Experiment results show that the watermarked image with this method has the biggest imperceptibility with the best PSNR when compared with other gray-scale watermarking schemes.

FA7.3 P0879 1040 - 1100
Vision-Based Lane Departure Detection System in Urban Traffic Scenes

Yu-Chi LENG, Chieh-Li CHEN
National Cheng-Kung University
A lane-departure detection system without intrinsic and extrinsic camera parameters calibration is proposed in this paper. The proposed system, which provides driving safety by lane detection and lane departure warning, is focused on urban road with complicated lane marks instead of simple highway scenes. Due to the complexity of urban traffic scenes, false lane detections are highly caused by warning lines and signs whose shape and color are similar to the lane boundary. In this study, two lane features, lane width and lane boundary continuity, are proposed to obtain reliable and quality lane detected results on urban traffic scenes. Lane departure warning decisions are then applied to provide driving safety. Experimental results of urban road sceneries have demonstrated feasibility and robustness of the proposed method.

FA7.4 P0916 1100 - 1120
A Method for the Segmentation of Connected Handwritten Persian Digits
Fattaneh TAHERI ASHTIYANI, *Karim FAEZ
Islamic Azad University, Bonab
*Amirkabir University of Technology, Tehran

This article presents in two modules a new method for segmenting connected handwritten Persian digits using the characteristics of the foreground and utilizing the background skeleton. The first module excavates all the valleys and hills, if there are any, from the upper pixels and lower pixels of the thinned image respectively. Then feature point excavate. For better segmentation the digits, a separability degree is calculated, regarding the height of the hills and valleys close to each feature point considering the characteristic of connected Persian digits. Then the significance degree is calculated to determine of its influence rate in segmentation. Then, using that, one or few points with high significance degree, which are more influence in the segmentation, are selected as the cutting points. Having excavated the background skeleton, the second module begins to identify the priority points in the skeleton in order to connect them to the cutting points. The conducted experiments confirm the accuracy of the factors utilized and the results indicates a correct segmentation at a rate of 97.2%.

FA7.5 P0188 1120 - 1140
A 3D Reconstruction System based on Improved Spacetime Stereo
Federico TOMBARI, Luigi DI STEFANO, Stefano MATTOCCIA, Andrea MAINETTI
University of Bologna

Spacetime stereo is a promising technique for accurate 3D reconstruction based on randomly varying illumination and temporal integration of the stereo matching cost. In this paper we show that the standard spacetime stereo approach can be improved in terms of accuracy of disparity estimation and convergence speed by adoption of suitable matching algorithms based on adaptive support windows. We also present a practical and cost-effective 3D reconstruction system that deploys the proposed improved spacetime method together with cheap commercial off-the-shelf hardware (a PC, a stereo camera and a projector). Experimental results show that the proposed system can yield rapidly accurate 3D reconstruction of various types of objects and faces.
Session FM1
Date:  Friday, 10 December 2010
Time:  1310 - 1510
Venue: Ball Room

Control Applications I
Chairs: Kirsten Moelgaard Nielsen
Aalborg University

FM1.1 P0463 1310 - 1330
Precision Motion Control for the Parallel Mechanism of Virtual Axis Machine Tool
Guoqin Gao, Yan Luo, Daogen Jiang, *Xinjun Liu
Jiangsu University
*Tsinghua University

The precision motion control problem of a virtual axis machine tool is addressed in this paper, which is still one of the biggest obstacles of commercialization of the virtual axis machine tool. Firstly, the kinematics analysis of the parallel mechanism of a 6-DOF virtual axis machine tool is made. Secondly, a joint-space trajectory planning based on the cycloid movement is conducted to ensure the stability of the mechanism movement. Finally, according to the characteristics of the parallel mechanism of the virtual axis machine tool, a novel completely chattering-free sliding mode control system is designed to achieve the high-precision control of the virtual axis machine tool. The simulation results show that the control system has a good performance in tracking and anti-interference and can achieve the accurate control of the branches of the virtual axis machine tool. Furthermore, it is not necessary to establish the accurate mathematical model of the parallel mechanism of the virtual axis machine tool and easy to design and implement.

FM1.2 P0258 1330 - 1350
Designing and Simulating of H∞ Controller for Flexible Aircraft
Wen-Jie Meng, Ai-Jun Li, Jian Tan, Chang-Qing Wang
Northwestern Polytechnical University

Reduction is essential in controller design for flexible aircraft, leading to model uncertainty and modeling error. It is difficult to ensure robust stability by conventional controller. In order to resolve that problem, a robust controller, which can not only control flexible aircraft attitude but can also restrain structure vibration quickly, is designed using mixed sensitivity control method. The controller is reduced to fourth-order and sixth-order by balanced truncation. Controlling effects of the reduction controller are studied by simulating. Simulation results show that compared with full-order controller, response performance of attitude angles using sixth-order controller is not affected and the controlling effect for fourth-order structure transform mode of aircraft is also roughly the same. Fourth-order controller can make attitude angle of aircraft and vibration of structure transform mode stable and the stable time is similar to full-order controller.

FM1.3 P0824 1350 - 1410
Temperature and Humidity Control in Livestock Stables
Michael Hansen, Palle Andersen, Kirsten Moelgaard Nielsen, Tom Soendergaard Pedersen, *Martin Riisgaard-Jensen
Aalborg University
*SKOV A/S

The paper describes temperature and humidity control of a livestock stable. It is important to have a correct air flow pattern in the livestock stable in order to achieve proper temperature and humidity control as well as to avoid draught. In the investigated livestock stable the air flow is controlled using wall mounted ventilation flaps. In the paper an algorithm for air flow control is presented meeting the needs for temperature and humidity while taking the air flow pattern in consideration. To obtain simple and realisable controllers a model based control design method is applied. In the design dynamic models for temperature and humidity are very important elements and effort is put into deriving and testing the models. It turns out that non-linearities are dominating in both models making feedback linearization the natural design method. The air controller as well as the temperature and humidity controllers are tested with promising results in a full scale test stable.

FM1.4 P1024 1410 - 1430
Backstepping Based Nested Multi-Loop Control Laws for a Quadrotor
Erik de Vries, *Kamesh Subbarao
Technical University of Delft
*The University of Texas at Arlington

Quadrotors are suitable testbeds for several point to point hover based surveillance and observation tasks. As such, the hover mode is a very important mode of operation for a quadrotor platform. This paper describes the design of a hover mode controller using a backstepping based multi-loop design for a linearized quadrotor dynamics. This controller is then tested using both the linear and a full nonlinear simulation model of the quadrotor.

FM1.5 P1032 1430 - 1450
Invariant Sets Techniques for Buck DC-DC Converter Control
Anamaria Luca, Pedro Rodriguez-Ayerbe, Didier Dumur, Pierre LeFranc
SUPELEC

This paper presents a simple and effective method for feedback law synthesis using invariant sets techniques. Given a time-varying Buck DC-DC converter affected by perturbations and constraints, the proposed method gives the best feedback gain in
In order to reduce the invariant set conservativeness for the designed feedback gain, a new maximal invariant set is searched using truncated-ellipsoids.

**FM1.6 P1064 1450 - 1510**

**Nonlinear 3-D Trajectory Guidance for Unmanned Aerial Vehicles**

Mousumi AHMED, Kamesh SUBBARAO

The University of Texas at Arlington

In this paper, we propose a backstepping based nonlinear guidance controller, designed for 3-D path tracking for a UAV. The guidance law design assumes first order dynamics for the speed, heading and elevation angles. We demonstrate closed loop stability via Lyapunov analysis. The efficacy of the controller is demonstrated for two cases, namely the straight path following and a curved path following.

**Session FM2**

**Date:** Friday, 10 December 2010  
**Time:** 1310 - 1510  
**Venue:** Canary

**Delay Systems**

**Chairs:** Pedro ALBERTOS  
*Universidad Politècnica de Valencia*  
Chengkang XIE  
*Southwest University*

**FM2.1 P0229 1310 - 1330**

**Sensor Fusion of Delay and Non-delay Signal using Ensemble Kalman Filter with Moving Covariance**

Yucheng ZHOU, Jiahe XU  
Chinese Academy of Forestry

This paper describes the design of ensemble Kalman filter (EnKF) to implement fusion of the delay and non-delay data for nonlinear discrete-time system in order to achieve the excellent dynamic response. We proposed a fusion method with EnKF that only needs to update the stored covariance between two different time instants, instead of classical method, which is re-performing Kalman operation at every step from the time of measured delay signal to current time. To solve the fusion method, the EnKF algorithm is modified to obtain members of measurement ensemble from uncorrelated sensors in the system but not a Monte Carlo method. With less computational cost comparing to the classical method and the uniformity of the computation in every iteration, the EnKF is superior to extended Kalman filter (EKF) and offer much advantage in terms of estimation performance, which is verified by using MATLAB simulation on the high-update rate Wheel Mobile Robot (WMR).

**FM2.2 P0438 1330 - 1350**

**Synchronization of Non-autonomous Chaotic Systems with Time-Varying Delay via Delayed Feedback Control**

Thongchai BOTMART, Piyapong NIAMSUP, *Xinzhi LIU*  
Chiang Mai University  
*University of Waterloo*

In this paper, we investigate the synchronization of non-autonomous chaotic systems with time-varying delay via delayed feedback control. Using a combination of Riccati differential equation approach, Lyapunov-Krasovskii functional, inequality techniques, some new sufficient conditions for exponentially stability of the error system are formulated in form of a solution to the standard Riccati differential equation. The designed controller ensures that the synchronization of non-autonomous chaotic systems are proposed via delayed feedback control. Numerical simulations are presented to illustrate the effectiveness of these synchronization criteria.
Impulsive Exponential Stabilization of Discrete Population Growth Models with Time Delays
Yu ZHANG, Jitao SUN
Tongji University
The purpose of this paper is to investigate the impulsive exponential stabilization for the positive equilibrium points of a class of discrete population growth models with time delays. By using Lyapunov functionals, some new exponential stability criteria are given. It is shown that impulses can indeed make unstable equilibrium points exponentially stable, and when the impulses are employed to stabilize the unstable equilibrium points, the time interval between the nearest two impulses should be small enough, i.e., impulses should act frequently. Two examples are also presented to illustrate the effectiveness of the obtained results. It should be noted that, it’s the first time that impulsive exponential stabilization results for discrete population models with time delays have been given.

Control of Unstable PDE with Long Input Delay
Yangyang ZHANG, Chengkang XIE
Southwest University
It is well known that control of PDEs with input delay is just opening up for research. This paper presents boundary control design and stabilization for a reaction-diffusion PDE with diffusion coefficients depending on space variable and input time delay. The control design involves an interesting structure of two interconnected PDEs to transfer the input time delay into a space extension. And the stability analysis is characterized in terms of the $\mathcal{H}^1$ norm of the actuator state rather than the usual $L^2$.

Robust Stabilization of 2-D State-delayed Systems with Stochastic Perturbation
Juan YAO, Shuxia YE, Weiqun WANG
Nanjing University of Science and Technology
Delay systems may be encountered stochastic perturbation, and the stability conditions of such systems are different from delay systems and stochastic systems. This paper considers the problems of robust stabilization for 2-D state-delayed system in Roesser model (RM) with stochastic perturbation for the first time. Delay-dependent sufficient stability conditions are derived in terms of linear matrix inequalities (LMIs). A state feedback controller is designed to ensure robust mean-square stability of the closed-loop system. An example is provided to demonstrate the effectiveness of the proposed approach.

Decoupling MIMO Systems with Multiple Input/Output Time Delays
Pedro ALBERTOS, Pedro GARCIA GIL
Universidad Politécnica de Valencia
Decoupling multi-input multi-output systems is a simplifying technique to design, implement and tune control systems. If there are also multiple delays, the decoupling is even more interesting although there is always a prize to pay and the resulting controllers can become excessively complex. In this paper a new approach to deal with these situations is presented. The procedure involves extracting non-delayed information to generate the control and canceling the interactions by means of disturbance observers. The approach is general and it can be applied to unstable plants.
Session FM3
Date: Friday, 10 December 2010
Time: 1310 - 1450
Venue: Kingfisher

Mobile Robotics III
Chairs: Sai Hong TANG
University Putra Malaysia
Yongduan SONG
Beijing Jiaotong University

FM3.1 P0421 1310 - 1330
A Novel Approach to Motion Modeling using Fuzzy Cognitive Map and Artificial Potential Fields
Omid Reza ESMAEILI MOTLAGH, Sai Hong TANG, Abdul Rahman RAMLI, Napsiah ISMAIL, D. Nakhaei NIA
University Putra Malaysia

Artificial potential field (APF) is well established for reactive navigation of robots. Initially, this paper describes a fast and robust fuzzy-APF on an ActivMedia AmigoBot platform. Obstacle-related information is fuzzified just by sensory fusion which results in shorter runtime. The membership functions of obstacles’ range and direction have been also merged into one function for smaller block of rules. The fuzzy-APF is tested and verified virtually with non-concave obstacles. Main contribution of this article is a new approach to motion modeling. The goal is to discover decision making behaviors of the robot in wayfinding. A novel decision modeling technique is developed based on capabilities of the fuzzy cognitive map (FCM) and supervised learning using the genetic algorithm (GA). Decision productions for moving from one sub-space to another are modeled in form of decision matrices. The robot trajectory under supply of such decision matrices has likelihood of nearly 90% with its trajectory under the APF. Replication of robot motion is therefore achieved by modeling its decision behaviors in form of tangible matrices.

FM3.2 P0535 1330 - 1350
Mobile Robot Localization using Feature Based Fuzzy Map Matching
Haoming XU, John James COLLINS
University of Limerick

This paper presents a novel scan matching approach entitled Fuzzy Map Matching for mobile robot localization that extracts low level features in the form of line segment from perceptual channels that are then matched to a map given a priori. Multiple candidate matches are supported through the use of fuzzy logic, which are iteratively refined. This probabilistic based fuzzy model of scan matching is used to filter the alignment combination that have low probability in order to reduce computational complexity. In addition, the initial pose of the robot does not have to be known as a result of support for multiple hypotheses with respect to potential correspondences. Incomplete line segments that result from incomplete scans, noisy sensors, or occlusion do not present a problem as features in observation space are grown during the correspondence phase of the algorithm. This approach does not impose a heavy demand on computational resources, and is significantly less resource hungry than the probabilistic approaches. Initial results demonstrated that the algorithm performs well in real world environments.

FM3.3 P0660 1350 - 1410
tinySLAM : A SLAM Algorithm in less than 200 Lines C-Language Program
Bruno STEUX, Oussama EL HAMZAOUI
Mines ParisTech

This paper presents a Laser-SLAM algorithm which can be programmed in less than 200 lines C-language program. The first idea aimed to develop and implement a simple SLAM algorithm providing good performances without exceeding 200 lines in a C-language program. We use a robotic platform called MinesRover, a six wheels robot with several sensors. We based our work and calculations on a laser sensor and the odometry of the robot. The article presents the different capabilities of the platform and the way we use them in order to improve our programs. We also illustrates the difficulties encountered during the programming and testing of the algorithm. This work shows the possibility to perform complex tasks using simple and easily programmable algorithms.

FM3.4 P0680 1410 - 1430
A DSP FPGA Based Hardware-in-the-Loop Testing Platform
Ta-ming SHIH, *Ho-Chung CHANG
Ming Dao University
*Chung Cheng Institute of Technology

Applying low-cost sensors for flight control is of extreme challenge due to less accuracy nature of sensors. Therefore a Hardware-in-the-Loop(HIL) is most necessary for test and evaluation purpose to reduce the risk of flight testing. In this paper, a HIL system is built up to test the autopilot hardware performance, control parameter tuning. By combining the commercial X-Plane fly simulation software and the DSP and FPGA(Field Programmable Gate Array) based hardware interfaces, a 3D visualize HIL platform is built to improve test efficiency and reducing time and cost.

FM3.5 P1038 1430 - 1450
A Fast Scan Matching for Grid-based Laser SLAM using Streaming SIMD Extensions
Oussama EL HAMZAOUI, Bruno STEUX
Mines ParisTech

The scan matching is one of the basic elements of several SLAM (Simultaneous Localization and
There are a lot of researches that are interested in scan matching, but the majority deals with the algorithmic side only, without worrying about implementation tricks that can be very useful. This paper presents a simple and effective method to accelerate the scan matching step. Our method uses the computing power offered by the SSE instructions. These instructions, developed by Intel, allows the processing of several data simultaneously. This method does not require the use of a specific hardware (GPU for example), because SSE instructions exist in the majority of the commonly used processors (Intel, AMD). The examples and programs presented in the article are part of our SLAM algorithm, developed in the Robotics Center of Mines ParisTech.

**Session FM4**

**Date:** Friday, 10 December 2010  
**Time:** 1310 - 1510  
**Venue:** Nightingale

### Factory Modeling and Simulation

**Chairs:** Dieter ZOEBEL  
*University Koblenz-Landau*  
Daoping LI  
*Beijing Institute of Technology*

**FM4.1 P0243 1310 - 1330**

**Generic Data Types for Planning and Control in Intermodal Freight Transshipment Applications**

*Dieter ZOEBEL, Christian WEYAND*  
*University Koblenz-Landau*

Planning and control environments for automated guided vehicles are predominantly dedicated to specialized vehicles, e.g. special carriers used in harbor areas for the transport of containers between quays and stackyards. The environment is completely different for commercial standard vehicles when operated under automated guidance. Typically, these are articulated vehicles with a high degree of variability, particularly with respect to their geometric and kinematic properties. Adaptivity requirements have to be taken into account and lead to the design and development of data types with a high degree of genericity. How planning and control depend upon these data types is explained in the broader scope of a new intermodal role-on, roll-off traffic concept which is currently under research. Furthermore, the data types play a central role in the validation process to achieve the legal approval for the automated guided traffic of standard commercial vehicles.

**FM4.2 P0470 1330 - 1350**

**Periodic Stable Robustness of Serial Production Line with Single Processing Parameter Perturbation based on Max-algebra**

*Daoping LI, Xiao-Lan YAO, Qinghe WU, Xiao-Dong ZHANG*  
*Beijing Institute of Technology*

The periodic stable robustness of serial production line with single processing parameter is analyzed based on max-algebra. A searching algorithm based on golden section method to calculate the bound of perturbation of processing parameter is also proposed. Example shows that the algorithm can get the bound of the perturbation effectively, which is meaningful to actual serial production line.

**FM4.3 P0901 1350 - 1410**

**Ontology-Based Product Knowledge Integration in Mobile Environment**

*Cao LI, Zongwu XIE, Kui SUN, Hong LIU, *Yongjun ZHENG*
This paper is to develop an ontology-based mobile environment for collaborative product design and manufacture, which enables geographically dispersed team members to collaborate over the internet within the total design or manufacturing process, including product design specification, conceptual design, detail design, manufacture and recycling. In this paper, a database which based on a new method named ontology is built up to demonstrate the all related information in order to achieve an efficient and convenient management. According these two achievements, a new data management system is built and tested in the mobile device and compared to the traditional data management system at the end of this paper.

FM4.4  P0917  1410 - 1430
Model Simplification for Accelerating Simulation-based Evaluation of Dispatching Rules in Wafer Fabrication Facilities
Tsung-Che CHIANG
National Taiwan Normal University

Dispatching rules are widely used for scheduling of wafer fabrication facilities, and simulation is a popular tool for evaluation of rules. A main weakness of simulation is the long computation time. In this paper, we aim at simplifying the models of fabrication facilities to reduce simulation time and meanwhile keep the ability of evaluating rules correctly. We propose a metric to assess how well a simplified model evaluates rules and formulate the model simplification problem as a multiobjective optimization problem. We also develop an evolutionary algorithm to solve the formulated problem. Experimental results show that simplified models generated by the proposed algorithm can save half of simulation time and select high-performance rules.

FM4.5  P0620  1430 - 1450
Binary Neural Network Classifier and it's Bound for the Number of Hidden Layer Neurons
Narendra S CHAUDHARI, *Aruna TIWARI
Indian Institute of Technology, Indore
*SGS Institute of Technology and Science, Indore

In this paper, a Binary Neural Network Classifier (BNNC) is proposed in which hidden layer training is done in parallel. Learning Algorithm for the BNNC is described, which is based on the principle of Fast Covering Learning Algorithm (FCLA) proposed by Wang and Chaudhari [1]. The BNNC offers high degree of parallelism in hidden layer formation. Each module in the hidden layer of BNNC is exposed to the patterns of only one class. For achieving better accuracy, issue of overlapped classes are also handled. The method is tested on few benchmark datasets, accuracies are within the acceptable range. Due to parallelism at hidden layer level, training time is decreased, therefore, it can be used for voluminous realistic database. An analytical formulation is developed to evaluate the number of hidden layer neurons, it is in the O(log(N)), where N represents the number of inputs.

FM4.6  P0831  1450 - 1510
Predicting Amount of Saleable Products using Neural Network Metamodels of Casthouses
Abbas KHOSRAVI, Saeid NAHAVANDI, Doug CREIGHTON, Bruce GUNN
Deakin University

This study aims at developing abstract metamodels for approximating highly nonlinear relationships within a metal casting plant. Metal casting product quality nonlinearly depends on many controllable and uncontrollable factors. For improving the productivity of the system, it is vital for operation planners to predict in advance the amount of high quality products. Neural networks metamodels are developed and applied in this study for predicting the amount of saleable products. Training of metamodels is done using the Levenberg-Marquardt and Bayesian learning methods. Statistical measures are calculated for the developed metamodels over a grid of neural network structures. Demonstrated results indicate that Bayesian-based neural network metamodels outperform the Levenberg-Marquardt-based metamodels in terms of both prediction accuracy and robustness to the metamodel complexity. In contrast, the latter metamodels are computationally less expensive and generate the results more quickly.
Session FM5 - Invited Session

Date: Friday, 10 December 2010
Time: 1310 - 1450
Venue: Pelican

Human Robot Interaction

Chairs: Sarath KODAGODA
*University of Technology, Sydney
Rajesh Elara MOHAN
Singapore Polytechnic
*Singapore polytechnic
**Nanyang Technological University

FM5.1 P0842 1310 - 1330
Experimenting Extended Neglect Tolerance Model for Human Robot Interactions in Service Missions

Rajesh Elara MOHAN, *Carlos A ACOSTA CALDERON, Changjiu ZHOU, **Wijerupage Sarada WIJESOMA
Singapore Polytechnic
*Singapore polytechnic
**Nanyang Technological University

In this paper, we validate the extended neglect tolerance model for estimation of human robot team performance in relation to robot autonomy and compare its results with the traditionally adopted neglect tolerance model which assumes zero false alarms in human robot interactions. Extended neglect tolerance model estimates robot performance in human robot teams, where the human operator switches control between robots sequentially, based on acceptable performance levels, taking into account any false alarms and their respective demands. Experiments were performed with Robo-Erectus@Home, a service robot across tele-operation, and semi-autonomous modes of autonomy where a human operator controlled the robot to perform a walking assistant task. Measured false alarm demands and robot performances were largely consistent with the extended neglect tolerance model predictions for both autonomy modes. We also compared traditionally adopted neglect tolerance and extended neglect tolerance model for the same experimental design. The results showed that the latter offers better estimates of robot performance and attention demands, due to the inclusion of false alarms into the model.

FM5.2 P0981 1330 - 1350
Modelling of Human Motor Control in an Unstable Task through Operational Space Formulation

Shou-Han ZHOU, Denny OETOMO, Iven MAREELS, *Etienne BURDET
The University of Melbourne
*Imperial College, London

Human motor control computational model is an important component in the study and the successful realisation of human-robot interaction. In this paper, the Operational Space Formulation is presented as a suitable framework of human motor control computational model based on the Equilibrium Point Hypothesis (EPH) approach. The iterative adaptive control strategy was incorporated to simulate human motor adaptation to different tasks. The strategy involves the use of an Equilibrium Model which represents the ideal human motor response to a given task. The combined strategy was simulated to match a set of data gathered experimentally from several human subjects. The results were observed to explain many of the features found in the recorded behaviours in the EPH-based approach of human motor modelling.

FM5.3 P0993 1350 - 1410
Using Common Motion Patterns to Improve a Robot’s Operation in Populated Environments

Stephan SEHESTEDT, Sarath KODAGODA, Gamini DISSANAYAKE
University of Technology, Sydney

Robotic devices are increasingly penetrating the human work spaces as stand alone units and helpers. It is believed that a robot could be easily integrated with humans, if the robot can learn how to behave in a socially acceptable manner. This involves a robot to observe, learn and comply with basic rules of human behaviors. As an example, one would expect a robot to travel in an environment without intruding human workspace unnecessarily. Thus, identifying common motion patterns of people by observing a specific environment is an important task as people’s trajectories are usually not random, however are tailored to the way the environment is structured. We propose a learning algorithm to construct a Sampled Hidden Markov Model (SHMM) that captures behavior of people through observations and then demonstrate how this model could be exploited for planning socially aware paths. Experimental results are presented to demonstrate the viability of the proposed approach.

FM5.4 P1042 1410 - 1430
Thinking Head: Towards Human Centred Robotics

Damith C HERATH, Christian KROOS, Catherine J STEVENS, *Lawrence CAVEDON, **Prashan PREMARATNE
University of Western Sydney
*RMIT University
**University of Wollongong

Thinking Head project is a multidisciplinary approach to building intelligent agents for human machine interaction. The Thinking Head Framework evolved out of the Thinking Head Project and it facilitates loose coupling between various components and forms the central nerve system in a multimodal perception-action system. The paper presents the overall architecture, components and the attention system. The paper then concludes with a preliminary behavioral experiment that studies the intelligibility of the audiovisual speech output produced by the Embodied Conversational Agent.
A fuzzy direct adaptive control strategy is proposed for the trajectory tracking control of robotic manipulators. Different to the traditional fuzzy adaptive control method, a generalized hyperbolic model is used to be the fuzzy basis function. The input generalized variables of the fuzzy logic system, derived from the input variables after their transformation, can cover with the whole input space. Thus, the fuzzy logic system can approximate the desired control input by an arbitrary accuracy. Furthermore, due to the special structure of the fuzzy hyperbolic model, the adaptive fuzzy control strategy needs only fewer updated parameters so that it can avoid a heavy computational burden but getting a satisfied tracking performance. Simulation studies are presented to show that this control algorithm has an expected tracking accuracy.
processor. The system was synthesized onto a Xilinx Virtex-5 XC5VSX50T using Xilinx ML506 development board and the implementation results are presented.

**FM6.3 P0844 1350 - 1410**

**Omnidirectional Video Stabilisation on a Virtual Camera using Sensor Fusion**

Thomas ALBRECHT, Tele TAN, Geoff A WEST, *Thanh LY
Curtin University of Technology
*Defence Science and Technology Organisation

This paper presents a method for robustly stabilising omnidirectional video given the presence of significant rotations and translations by creating a virtual camera and using a combination of sensor fusion and scene tracking. Real time rotational movements of the camera are measured by an Inertial Measurement Unit (IMU), which provides an initial estimate of the ego-motion of the camera platform. Image registration is then used to refine these estimates. The calculated ego-motion is then used to adjust an extract of the omnidirectional video, forming a virtual camera that is focused on the scene. Experiments show the technique is effective under challenging ego-motions and overcomes deficiencies that are associated with unimodal approaches making it robust and suitable to be used in many surveillance applications.

**FM6.4 P0852 1410 - 1430**

**Square Patch Feature: Faster Weak-Classifier for Robust Object Detection**

Yasir MOHD MUSTAFAH, *Abbas BIGDELI, Amelia Wong AZMAN, *Farhad DADGOSTAR, Brian C LOVELL
The University of Queensland
*National ICT Australia

This paper presents a novel generic weak classifier for object detection called "Square Patch Feature". The speed and overall performance of a detector utilizing Square Patch features in comparison to other weak classifiers shows improvement. Each weak classifier is based on the difference between two or four fixed size square patches in an image. A pre-calculated representation of the image called "patch image" is required to accelerate the weak classifiers computation. The computation requires fewer arithmetic operations and fewer accesses to the main memory in comparison to the well known Viola-Jones Haar-like classifier. In addition to the faster computation, the weak classifier can be extended for in-plane rotation, where each square patch can be rotated to detect in-plane rotated objects. The results of the experiments on the MIT CBCL Face dataset show that a Square Patch Feature classifier is as accurate as the Viola-Jones Haarlike classifier, and when implemented on hardware (i.e. FPGA), it is almost 2 times faster.

**Language Understanding**

Guangpu HUANG, Meng Joo ER
Nanyang Technological University

This paper shows that the integration of statistical and connectionist methods can greatly enhance human-computer interaction through speech. The research approach is inspired by recent advances in high performance automatic speech recognition (ASR) systems and neurocognitive researches of natural language understanding (NLU). And a modest hybrid computational model is proposed and implemented to achieve intelligent spoken language understanding (SLU) in an information retrieval system.

**FM6.6 P1142 1450 - 1510**

**Frontal Face Classifier using AdaBoost with MCT Features**

Jongmin YOON, Daijin KIM
POSTECH

In this paper, we describe how to classify frontal face from the results of face detection which include non-frontal faces. To do this, we use AdaBoost learning method with Modified Census Transform (MCT) to construct a two-class classifier. As a result of that, our frontal face classifier achieves high classification rate above 96% and fast performance about 10 frames/sec in mobile device.
This paper describes a new approach to object recognition and localization within unknown indoor environments. The system includes a GUI design through which the user may describe an object of interest by means of color, size, and shape. A novel coarse to fine identification mechanism that incorporates multiple views of an object is then used to locate the described object within an unknown environment. The system includes a training stage in which representative information is extracted from database images. A stereo vision system, mounted on an indoor robot platform (Fig. 1), is used to retrieve the 3D location of potential match candidates in the scene and to inspect possible matches from three distinct viewpoints. Experimental evaluation is performed for indoor environments and promising results are shown for the application of this system.

In this paper, we present a new object detection method using codebook and boosted Markov Chain Monte Carlo (MCMC) estimation. It is relatively well detected using adaboost and simple Haar-like features for small objects. However, the detection problem is more difficult when object size becomes larger (over 150 x 150) due to different surface markings and clutter. Codebook-based object representation and boosted MCMC method can detect large objects robustly. Experimental results validate convincing detection for large objects.

This paper describes a new approach to object recognition for active vision systems that integrates information across multiple observations of an object. The approach exploits the order relationship between successive frames to derive a classifier based on the characteristic motion of local features across visual sweeps. This motion model reveals structural information about the object that can be exploited for recognition. The main contribution of this paper is a recognition system that extends invariant local features (shape contexts) into the time domain by integration of a motion model. Evaluations on one standardized and one custom collected dataset from the humanoid robot in our laboratory demonstrate that the motion model allows higher-quality hypotheses about object categories quicker than a baseline system that treats object views as unordered streams of images.

Based on multiple kernel learning (MKL) support vector machine and decision tree combined strategy, a multi-class classification method is proposed to classify lower limb motions using electromyography (EMG) signals. According to the framework of multiple kernel learning, the MKL-based multi-classifier is constructed using binary tree decomposition method. Four-channel surface EMG signals are firstly collected from lower limb muscles, and then some time-domain features are extracted and inputted into the proposed multi-classifier. Five subdividing patterns are finally identified in level walking, i.e. support prophase, support metaphase, support telophase, swing prophase and swing telophase. The experimental results show that the proposed method can successfully identify these subdividing patterns with better accuracy than standard single-kernel support vector machine classifier.

Digital mammography is a preferred method for early detection of breast cancer. However, in most cases, it is very difficult to distinguish benign and malignant masses without a biopsy, hence, misdiagnosis is always possible. In this paper, the Extreme Learning Machine (ELM) algorithm is used to classify the suspicious masses in digitized mammograms available in the Mini-MIAS database. As selection of features is critical in efficient classification of mammograms, a study was conducted to identify the best features that make a
clear distinction between the malignant and benign masses. Then, the recently developed Extreme Learning Machine (ELM) based classifier is used to classify the benign and malignant cases. It is observed that the performance of the batch learning ELM algorithm is dependent on the number of hidden neurons, and the magnitude of input weight initialization. An extensive study is conducted to identify the best number of neurons to achieve the best training and testing classification performance. The performance results are then compared with the classification results, available in the literature. The performance study results show that the classification efficiency of the ELM classifier is better than the other existing algorithms, for the mammogram classification problem of the database considered for this study.

Session FP1 - Invited Session
Date: Friday, 10 December 2010
Time: 1600 - 1720
Venue: Ball Room

Underwater Robotics
Chairs: Norimitsu SAKAGAMI
Tokai University

FP1.1 P0959 1600 - 1620
Development of the Actuator Concentration Type Removable Underwater Manipulator
Fumiaki TAKEMURA, Reyes Tatsuru SHIROKU
Okinawa National College of Technology

Authors have been developing the actuator concentration type removable underwater manipulator. This manipulator has the following features. 1. This manipulator makes it relatively easy to waterproof due to actuator concentration. 2. Wireless LAN Access Point (AP) is installed in underwater robot and AP connects with operating PC by wire LAN. This manipulator has a few cameras to take a look operation. The command to each actuator of manipulator and camera image communicate with operating PC via wireless LAN. Therefore, the external signal wire for control has no use. 3. Removable is easy because this manipulator is connected with the underwater robot body only with the power cable. In this paper, we verify the feasibility of 2 by wireless LAN communication experiment using seawater. Moreover, we describe the design of manufactured actuator concentration type removable manipulator and the experimental result.

FP1.2 P0967 1620 - 1640
Adaptive Region Tracking Control for Autonomous Underwater Vehicle
Xiang LI, Saing Paul HOU, Chien Chern CHEAH
Nanyang Technological University

This paper presents an adaptive region tracking control for Autonomous Underwater Vehicle (AUV). The AUV is required to track a moving region to accomplish a given task. The desired target is specified as a region rather than a point so that the control effort used to track the region is minimal. In the applications where the accuracy is of utmost importance, the desired region can be chosen to be small so that the precision is not lost. The desired region can be scaled up or scaled down so that the AUV can adjust its position to suit the applications. A Lyapunov-like function is presented for the stability analysis. Simulation results on AUV with 6 degrees of freedom are presented to demonstrate the effectiveness of the proposed controller.

FM7.6 P0945 1450 - 1510
A Divide-and-Distribute Approach to Single-Cycle Learning HGN Network for Pattern Recognition
Anang Hudaya MOHAMMAD AMIN, Asad I. KHAN
Monash University, Melbourne

Distributed Hierarchical Graph Neuron (DHGN) is a single-cycle learning distributed pattern recognition algorithm, which reduces the computational complexity of existing pattern recognition algorithms by distributing the recognition process into smaller clusters. This paper investigates an effect of dividing and distributing simple pattern recognition processes within a computational network. Our approach extends the single-cycle pattern recognition capability of Hierarchical Graph Neuron (HGN) for wireless sensor networks into the more generic framework of computational grids. The computational complexity of the hierarchical pattern recognition scheme is significantly reduced and the accuracy is improved. The single-cycle learning capability, which develops within the HGN, shows better noisy pattern recognition accuracy when size of the clusters is adapted to pattern data. The scheme lowers storage capacity requirements per node and incurs lesser communication complexity while retaining HGN’s response-time characteristics. Higher recall accuracy and scalability of the scheme is tested by storing large numbers of binary character patterns and heterogeneous binary images. The results show that the response-time remains insensitive to the number of stored pattern, the accuracy is improved, and the system resource requirements are significantly reduced.
Robot Manipulators
Shunmugham R PANDIAN, *Norimitsu SAKAGAMI
Southeastern Louisiana University
*Tokai University

Autonomous underwater vehicles are increasingly replacing the prevalent remotely operated vehicle-manipulator systems. Most current generation AUVs are not fitted with manipulators and hence are mainly limited to underwater surveying and surveillance tasks because of the difficulty in the coordinated control of the resulting underwater vehicle-manipulator systems. While several researchers have proposed various techniques for control of AUVs, there is still much research to be done on the precise control of underwater manipulators. This paper presents an intelligent control method for underwater manipulators based on the neuro-fuzzy approach. The controller is composed of fuzzy PD control with feedback gain tuning by linguistic rules. A neural network compensator approximates the dynamics of the multiple degrees of freedom manipulator in decentralized form. The proposed controller has advantages of simplicity of implementation due to decentralized design, precision, and robustness to payload variations and hydrodynamic disturbances. It has lower energy consumption compared to the conventional PD control method. The effectiveness of the proposed controller is illustrated by experimental results for a three degrees of freedom underwater manipulator.

FP1.4 P1036 1700 - 1720
Design and Development of an Attitude Control System for a Human-sized ROV
Norimitsu SAKAGAMI, *Takafumi KANAYAMA,
**Tomohiro UEDA, **Hideki HASHIZUME, **Mizuhoro SHIBATA, ***Hiroyuki ONISHI, ***Shigeo MURAKAMI, **Sadao KAWAMURA
Tokai University
*DENSHI KOGYO CO., LTD.
**Ritsumeikan University
***DAINIPPON SCREEN MFG. CO., LTD.

In this paper, we present the design and development of an attitude control system for a human-sized ROV (Remotely Operated Vehicle) with a dual-manipulator system. The main operations of our ROV are sampling operations for biological researches, geological researches and archaeological explorations in Lake Biwa, the biggest lake in Japan. In order to achieve these operations, we propose an attitude control system and explain the availability of the proposed system in this paper. For the design of a prototype of the attitude control system, simulation analysis was conducted. Based on the analysis, a pitch angle control system was designed and developed as the prototype of the attitude control system. An experiment was conducted in a test tank to demonstrate the effectiveness of the proposed system. The result shows that the developed system is useful for pitch angle control of the ROV.

Session FP2
Date : Friday, 10 December 2010
Time : 1600 - 1800
Venue : Canary

Feature Extraction, Grouping and Segmentation II
Chairs : Tele TAN
Curtin University of Technology
Frederic MAIRE
Queensland University of Technology

FP2.1 P0212 1600 - 1620
A Unified 2D-3D Video Scene Change Detection Framework for Mobile Camera Platforms
Wilson Suryajaya LEOPUTRA, Tele TAN, Svetha VENKATESH
Curtin University of Technology

In this paper, we present a novel scene change detection algorithm for mobile camera platforms. Our approach integrates sparse 3D scene background modelling and dense 2D image background modelling into a unified framework. The 3D scene background modelling identifies inconsistent clusters over time in a set of 3D cloud points as the scene changes. The 2D image background modelling further confirms the scene changes by finding inconsistent appearances in a set of aligned images using the classical MRF background subtraction technique. We evaluate the performance of our proposed system on a number of challenging video datasets obtained from a camera placed on a moving vehicle and the experiments show that our proposed method outperforms previous works in scene change detection, which suggested the feasibility of our approach.

FP2.2 P0431 1620 - 1640
Flying Vision System of Placement Machine for MEMS Microphone
Liguo CHEN, Jifeng ZHU, Weibin RONG, Lining SUN
Harbin Institute of Technology

In the die bonding process of MEMS microphone chip, the exact center and rotate angle of MEMS microphone chip is corrected after the vacuum nozzle has adsorbed it. In order to achieve high speed and precision placement function, the flying vision system based on rotating mirror is proposed, the mirror is driven to rotate by the power drawn from the nozzle rise and fall movement through a rack and pinion mechanism, the nozzle pick and place functions is not interfered by mirror through designing the rack and pinion mechanism parameters. The vision system can capture an static clear MEMS chip image when the mirror rotated to a 45 degrees position referenced with horizontal position, the center position and rotating angle of MEMS chip is fast calculated by the fine and coarse Hough Transform Algorithm, the center location and angle will be corrected by the control system during the mounted head is flying to
placement position. The experimental results show that the system can obtain high-quality MEMS microphone chip image, the chip’s center position and rotating angle correction algorithm takes no more than 0.1s, so it can meet the high-speed placement requirements. In this proposed flying vision system, mechanical structure is simple and compact, MEMS chip’s image is clear without distortion, and there is no restriction on the mounted head movement trajectory. The flying vision system significantly enhances the quality and efficiency of SMD Chip; it can be widely used in the surface mounted system.

FP2.3  P0623  1640 - 1700
Improve Library Shelf Reading using Color Feature Matching of Book-Spine Images
Spencer G FOWERS, Dah-Jye LEE, *Guangming XIONG
Brigham Young University
*Beijing Institute of Technology

Many computer vision algorithms for pattern matching, object tracking, and 3-D reconstruction, etc., begin with feature detection and matching. Common feature detectors such as Harris, Sobel, Canny, and Difference of Gaussians perform basic linear algebra operations on an image in order to identify "corners" or "edges" for matching. These detectors however, require single-channel (grayscale) source images. For color source images, color channels are typically averaged or converted to create grayscale images for processing, discarding a large amount of highly useful information. This paper outlines the proposed color Difference of Gaussians (DoG) algorithm for feature detection, which outperforms the grayscale DoG in number and quality of features found. The new color DoG is applied to a color feature matching application for improving the library inventory (shelf-reading) process. Experimental results demonstrate the robustness of this color feature detector.

FP2.4  P0681  1700 - 1720
A Fast and Robust Descriptor for Multiple-view Object Recognition
Maja RUDINAC, Pieter P JONKER
Delft University of Technology

In this paper we propose a fast and robust descriptor for multiple view object recognition using a small number of training examples. In order to design a descriptor to be discriminative between many different object appearances, we base it on a combination of invariant color, edge and texture descriptors. We use a color descriptor based on a HSV histogram - as it is robust to size and position of the object -, a gray level co-occurrence matrix as texture descriptor and an edge histogram as shape descriptor. After extraction of feature vectors, we perform normalization on all feature vectors from the training database in order to increase the importance of the most dominant feature components and reduce the less dominant ones. This normalization improves the recognition performance with almost 30% in case of a small number of training objects and in case of noise or occlusion. We tested our descriptor on the Columbia Object Image Library dataset (COIL 100) which presents objects in scaled, translated and rotated versions. Our recognition rate is extremely high: 99% in case of a large number of training objects and 93% for training with only 4 views of the object, or 5% of the database. The descriptor was also tested under various distortions: illumination change, noise corruption and occlusions. It proved to be very robust, with recognition rates decreasing only less than 5%. We compared our results with state of the art methods and we conclude that our descriptor achieves a better performance, both on the regular COIL database and on all distorted variants.

FP2.5  P1090  1720 - 1740
Obstacle-Free Range Determination for Rail Track Maintenance Vehicles
Frederic MAIRE, *Abbas BIGDELI
Queensland University of Technology
*National ICT Australia

Maintenance trains travel in convoy. In Australia, only the first train of the convoy pays attention to the track signalization (the other convoy vehicles simply follow the preceding vehicle). Because of human errors, collisions can happen between the maintenance vehicles. Although an anti-collision system based on a laser distance meter is already in operation, the existing system has a limited range due to the curvature of the tracks. In this paper, we introduce an anti-collision system based on vision. The two main ideas are, (1) to warp the camera image into an image where the rails are parallel through a projective transform, and (2) to track the two rail curves simultaneously by evaluating small parallel segments. The performance of the system is demonstrated on an image dataset.

FP2.6  P0659  1740 - 1800
Recognizing Human Motions from Surrounding Viewpoints Employing Hierarchical Eigenspaces
S. M. ASHIK EFTAKHAR, Joo Kooi TAN, Hyoungseop KIM, Seiji ISHIKAWA
Kyushu Institute of Technology

The development of an automatic human motion recognition system leads to the solution to the problems concerning the video-based applications in recognizing human activities. Such a system is to be investigated in the context of human motion analysis. Although there were a large number of researches in this area for a long time, there was little attention given to the development of a structured database for successful retrieval of motion data incorporating the time-space trade-off. We have proposed a system which is capable of dealing with large set of motion data employing an efficient database structure with
improved performance. We have analyzed two motion representation techniques to realize the effectiveness of the system. Performance evaluation is performed by synthesized 3D human motions observed from eight camera directions. Finally, our results show that the proposed recognition scheme performs well for the captured motions.

**Session FP3**

**FP3.1 P0983 1600 - 1620**

**An Intelligent Control Approach for Blood Pressure System using Self-generating Fuzzy Neural Networks**

Fan LIU, Meng Joo ER
Nanyang Technological University

This paper presents an intelligent control approach for blood pressure system using self-generating fuzzy neural networks (SGFNN). The proposed SGFNN is simple and effective and is able to generate a fuzzy neural network to model unknown nonlinearities of complex blood pressure system. This paper investigates the use of fuzzy neural network technique for modeling and automatic control of mean arterial pressure (MAP) through the intravenous infusion of sodium nitroprusside (SNP). Simulation studies based on a sensitive model of MAP illustrate the ability of the proposed approach in modeling drug delivery system and control postsurgical blood pressure.

**FP3.2 P0455 1620 - 1640**

**Neural Network Based Minimal State-Space Representation of Nonlinear MIMO Systems for Feedback Control**

Kristina VASSILJEVA, Eduard PETLENKOV, Juri BELIKOV
Tallinn University of Technology

A state-space technique for control of nonlinear multi-input multi-output (MIMO) systems identified by an Additive Nonlinear Autoregressive eXogenous (ANARX) model is presented. Controlled system is identified by Neural Network based Simplified Additive NARX (NN-SANARX) model linearized by dynamic feedback. The neural network based model is represented in the discrete-time state-space form. The problem of finding the minimal state-space representation is considered.

**FP3.3 P1008 1640 - 1700**

**Metrics for Measurement of Additive Noise to Weight in Sigmoidal FFANNs**

Amit Prakash SINGH, Chandra Shekhar RAI, *Pravin CHANDRA*
GGS Indraprastha University
*University of Delhi South Campus*
Feedforward artificial neural networks are susceptible to thermal noise when implemented as analog or digital hardware. Thus to study the effect of noise on neural hardware, noise metrics have to be identified. In this paper, five new metrics are prepared and shown to be relevant for noise modeling in the neural hardware.

**FP3.4 P0534 1700 - 1720**

**Fuzzy Metering Control on the Auxiliary Road Signal of the Expressway Exit**

*Changliang YUAN, Honghai LI*

Research Institute of Highway Ministry of Transport

This paper gives the basic description of fuzzy metering control of the auxiliary road signals. On the base of this description, the basic fuzzy logic control structure and fuzzy control algorithm are described. The necessity of using the exit- auxiliary-road density as the fuzzy metering control objective is analyzed. The real membership function is used in the design process of the auxiliary road fuzzy controller. The XueYuan Road exit on the second ring road in Beijing is selected as the study object in the simulation, and the simulation results reflect the adjustment results of the fuzzy controller with the present fuzzy control rules. The metering rate only changes a little. However, when the average delay is selected as the evaluation parameter, the fuzzy metering control will produce less delay than the field cycle-split control strategy. The exit delay of the expressway decreases 66%. The delay of the auxiliary road downstream of the stop line decreases 93%.

**FP3.5 P0743 1720 - 1740**

**Designing a Fuzzy Logic Controller to Adjust the Angle of Tires in Four Wheel Steering Vehicles**

*Ali HAKIMA, Sina AMELI*

Qazvin Islamic Azad University

In this paper, a 4 wheel steering vehicle (4WS) was used as a template and a vehicle was modeled (experimental) by using 2 degree of freedom system. The dynamics governing the Yaw behavior of a vehicle has been simulated with MATLAB/SIMULINK software. A controller, working by fuzzy logic was then designed. A relationship between front and rear angle of tires in different speeds and different front steering angle was found after running simulation for over 600 times. This controller increases the directional stability property of experimental vehicle when this vehicle is turning or maneuvering. The relationship was then used to make rules for the fuzzy logic controller. Subsequently, the experimental vehicle was compared with an uncontrolled vehicle and a vehicle with a very high lateral stiffness which there is infinitesimal slipped on turning or maneuvering (reference). This allows us to correctly identify the amount of slipping in our experimental vehicle. Our results show significant improvement of directional stability property of experimental vehicle in comparison with uncontrolled vehicle in different speed and different steering angles. Also the gotten results show that the side slip angle and the yaw rate of experimental vehicle were enhanced significantly.

**FP3.6 P0447 1740 - 1800**

**An Enhanced Online Self-organizing Fuzzy Neural Network**

*Linn SAN, Meng Joo ER, *Xiang LI, Lainyin ZHAI, Amin TORABI JAHROMI*

Nanyang Technological University

*Singapore Institute of Manufacturing Technology*

An Enhanced Online Self-organizing Fuzzy Neural Network (EOS-FNN) is proposed in this paper. The proposed algorithm can improve computational efficiency while achieving comparable performance and accuracy compared to other methods. The proposed EOS-FNN starts with an empty rule set and automatically generates fuzzy rules according to the proposed criteria during the learning process. All the parameters of the fuzzy rules are updated by the Extended Kalman Filter (EKF) method. Nonlinear time-series prediction processes are used to evaluate the performance of the proposed EOS-FNN algorithm with a comparison to other popular algorithms including DFNN, GDFNN and FAOS-PFNN. Simulation results have shown that the proposed algorithm reduces computation time while achieving comparable accuracy.
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<th>Session FP4</th>
<th>Date:</th>
<th>Friday, 10 December 2010</th>
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**FP4.1 P0833 1600 - 1620**

**Imoovement of Short-Span Seeking Performance in a Dual-Stage Hard Disk Drive Actuator**
Branišlav HREDZAK
The University of New South Wales

This paper proposes an alternative method to improve short-span seeking performance of a compensator based control system for a dual-stage servo actuator. The short-span seeking performance is improved by presetting initial conditions of the compensator during the short-span seek commands. This results in faster response of the secondary control loop and hence in faster seek times within the range of the secondary actuator. The performance of the proposed initial conditions based method is compared with the performance of recently proposed methods using constant and dynamic saturations in the secondary loop. The results show that the performance of the proposed method is comparable with the performance of the method using the dynamic saturation and thus can be used as an alternative, simpler method, to achieve faster short-span seek times.

**FP4.2 P0146 1620 - 1640**

**Stabilization of a Circular Ball-and-Beam System**
Aakash A RAVCHANDRAN, Arun D MAHINDRAKAR
Indian Institute of Technology, Madras

The ball on a circular beam system is an underactuated mechanical system that is challenging control problem compared to its variant: the ball on a horizontal beam. The control challenge stems out from the fact that the ball on a circular beam system has two unstable eigenvalues unlike its variant which has one. A stabilizing controller synthesized using backstepping methodology is presented. In doing so, a series of nonlinear coordinate transformations is applied on the equations of motion to arrive at a state-space representation which is in the so called quadratic non-triangular normal form. Simulation results are presented to demonstrate the effectiveness of the proposed controller in stabilizing the system while respecting the physical constraints on the system.

**FP4.3 P0471 1640 - 1700**

**Efficient Control System Development using Real-time Virtual Hardware-in-the-loop Simulation**
Jun ZHONG, Yi JIN, Guofu LIAN, Guoliang DING, Changan ZHU
University of Science and Technology of China

In this paper, an efficient control system development method based on real-time virtual hardware-in-the-loop simulation is presented. Instead of developing and testing control system after physical prototype is produced, it can be conducted immediately after concept of controlled system is designed by developing a pure software real-time simulator. In this simulator, all the hardware is virtual. The appearance and operation of these virtual hardware is programmed to imitate corresponding physical prototypes so as to implement real-time virtual hardware-in-the-loop simulation. So The control software and the control logic of control system can be developed quickly. And the source code is compatible with both the simulation platform and physical platform. Moreover, It’s much easier and faster to debug and test the control logic in such a way. An example of a large and high-groove density ruling engine is provided to explain detail implementation of the proposed method.

**FP4.4 P0604 1700 - 1720**

**Design and Development of a 4kW SMPS Power Supply with Long Term Short Circuit Capability**
Kosala JAYASUNDARA, Salinda TENNAKOON
University of Moratuwa

The design of high power AC-DC converters with higher efficiency is a challenging task, specially with the consideration of the long term short circuit withstand capabilities. This kind of power supplies are commonly used in Arc welding power supplies and other variable load supplies. This paper discusses about the design and implementation of a 4kW AC-DC converter with output voltage stability, current limiting and the long term short circuit withstand capability. Also a special type of snubber circuit is discussed. Index Terms — AC-DC converters, snubber design, short circuit protection, welding transformer

**FP4.5 P0925 1720 - 1740**

**A Unified Controller Design using two Different Types of Optimal Reset Control Laws for HDD Servo Systems**
Hui LI, Youyi WANG
Nanyang Technological University

This article proposes a unified reset control design method to achieve both track-seeking and track-following performance in hard disk drive servo systems. It involves a discrete Linear Quadratic Regulation (LQR) reset controller and an H₂ reset controller. The LQR reset controller is much capable of improving transient response performance which
includes fast raise time and little overshoot. The discrete H₂ reset controller performs a better disturbance rejection performance which is more suitable for track following stage. The unified control makes a soft switch from LQR reset controller to H₂ reset controller, which avoids sharp vibrations. Simulation shows that the unified reset controller inherits the merits of both discrete LQR reset controller and discrete H₂ reset controller, and achieves both swift seeking and accurate following performance.

**FP4.6 P0955 1740 - 1800**
**Model Predictive Control Based Efficient Operation of Battery Energy Storage System for Primary Frequency Control**
*Muhammad KHALID, Andrey V SAVKIN*
The University of New South Wales

This paper presents a method for an efficient operation of a battery energy storage system (BESS) associated with frequency control problem. A control system model is proposed to simulate the BESS for frequency control application. A controller based on model predictive control (MPC) is designed for the reliable operation of the BESS for primary frequency regulation. A frequency prediction model based on Grey theory is also designed to optimize the performance of our predictive controller. The method is tested using real measurements from a real power grid in the presence of multiple and realistic physical system constraints. The simulation results depict the effectiveness of the proposed frequency regulation scheme.

**Session FP5**
**Date:**  Friday, 10 December 2010  
**Time:**  1600 - 1800  
**Venue:**  Pelican

**Identification and Estimation II**
**FP5.1 P0687 1600 - 1620**
**Piecewise Linear Approximation of Sinusoidal Inputs for Process Identification**
*Salim AHMED*  
Qatar University

A new approach for simultaneous estimation of parameters and the time delay of continuous time transfer function models using piecewise linear input excitations is presented. A sinusoidal input can be approximated as a piecewise linear signal. Approximation equation for sinusoids has been provided and estimation equation for first order transfer functions has been derived which can be generalized for higher order models. Simulation results are presented to demonstrate the efficacy of the method. Identification results of a simulated jacketed reactor are presented to demonstrate the applicability of the proposed algorithm.

**FP5.2 P0554 1620 - 1640**
**Identification and Control of Nonlinear Systems using Piecewise Affine Models**
*Chow Yin LAI, Cheng XIANG, Tong Heng LEE*  
National University of Singapore

Piecewise affine model is a useful tool for approximating nonlinear systems. In this paper, we first propose a procedure for obtaining the piecewise affine ARX models of nonlinear systems. Two parameters which fully characterize a piecewise affine ARX model, namely the parameters of the locally linear/affine subsystems, as well as the partitions of the regressor space, will be estimated, the former through a least-squares based identification method using multiple models, and the latter using standard procedures such as neural network classifier or support vector machine classifier. Based on the piecewise affine ARX model of the nonlinear system, we then proceed to derive a model-based controller to control the system for reference tracking. Simulation studies show that our algorithm can indeed provide accurate piecewise affine approximation of nonlinear systems, and that the proposed controller provides good tracking performance.

**FP5.3 P0614 1640 - 1700**
**Nonparametric Modeling of Glucose-Insulin**
This paper deals with an identification problem of modeling a nonlinear dynamic system of multivariable glucose-insulin process in an IDDM patient. Out of many model structures that can represent a nonlinear process effectively; the Hammerstein-Wiener model has attracted a lot of attention. The present work proposes a generalized identification method of Hammerstein-Wiener model from the input-output data of multivariable nonlinear glucose-insulin process. The present algorithm consists of a three-block (LNL) realization. For the multivariable system, the first and third blocks are standard impulse response filter (IRF) realization applied to an equivalent linear system using adaptive recursive least square (ARLS) algorithms. In the second block, i.e. the nonlinear part, ARLS algorithms have been used to solve up to second order kernels of Volterra equations with extended input vector consisting of cross components as well. The input-output data taken from the simulated nonlinear process have been used to identify the system with a filter memory length of \( M = 3 \) and the validation results have shown good fit and in concordance with predicted output.
Session FP6
Date: Friday, 10 December 2010
Time: 1600 - 1800
Venue: Oriole

Robot Sensing, Perception and Data Fusion

Chairs: Vaidehi VIJAY  
Anna University, Chennai  
Sen ZHANG  
Singapore Polytechnic

FP6.1 P0894 1600 - 1620
Sound Source Target Localization System of Mobile Robot
Linan ZU, Peng YANG, Hao SUN, Lingling CHEN  
Hebei University of Technology

Target localization system is one of the basic aspects for mobile robot navigation. One of the most popular navigation way is the navigation based on visual. But, this way is limited by the light and the field of view so that it can’t accurately detect the targets in special environments. To resolve the above problem of target localization way based on visual, this paper has studied the sound source target localization system. The key technologies of this system have been discussed. They are the structure of the microphone array, the multi acoustic source separation in dynamic environment, sound source localization method in mixed noise environment, the time delay estimation method in the mixed-noise environment, multi-sensor information fusion, and so on. Finally, an auditory system based on microphone array was found to locate the sound source target of 3-D space and some emulational experiments validate the correctness of this auditory system and the accuracy and real-time of the sound source localization.

FP6.2 P0992 1620 - 1640
Binaural Speaker Recognition for Humanoid Robots
Karim YOUSSEF, Sylvain ARGENTIERI, Jean-Luc ZARADER  
Université Pierre et Marie Curie

In this paper, an original study of a binaural speaker identification system is presented. The state of the art shows that, contrarily to monaural and multi-microphone approaches, binaural systems are not so much studied in the specific task of automatic speaker recognition. Indeed, these systems are mostly used for speech recognition, or speaker localization. This study will focus on the benefits of the binaural context in comparison with monaural techniques. It demonstrates the interest of the binaural systems typically used in humanoid robotics. The system is first tested with monaural signals, and then with a binaural sensor, in many signal to noise ratios, speech durations and speaker directions. Up to 11 percent of improvement in recognition ratios of 23 ms frames can be obtained. The used database is a set of audio tracks recorded for 10 speakers, and filtered by HRTFs to obtain binaural signals in the directions of interest, for the binaural training and testing steps. This way, we study the sensitivity of the system to the speaker’s location in an environment where a maximum of 10 speakers is present.

FP6.3 P1046 1640 - 1700
A System for Reconstruction from Point Clouds in 3D: Simplification and Mesh Representation
Lyuba ALBOUL, Georgios CHLIVEROS  
Sheffield Hallam University

In this paper we present a complete system for acquisition of fused (textured) point clouds in 3D, from a Laser Range Finder (LRF) and a CCD camera. Furthermore, we describe an approach to build and process the resulting models, including their pre-processing and mesh simplification. This approach allows manipulating the resulting data structure into consistent geometric representations, which can be further adapted based on user requirements. The advantage of our system is that of low computational cost, ease of use and accuracy in the representation of the environment, even without prior data smoothing.

FP6.4 P0958 1700 - 1720
Multi-class Classification for Semantic Labeling of Places
Lei SHI, Sarath KODAGODA, Gamini DISSANAYAKE  
University of Technology, Sydney

Human robot interaction is an emerging area of research, where human understandable robotic representations can play a major role. Knowledge of semantic labels of places can be used to effectively communicate with people and to develop efficient navigation solutions in complex environments. In this paper, we propose a new approach that enables a robot to learn and classify observations in an indoor environment using a labeled semantic grid map, which is similar to an Occupancy Grid like representation. Classification of the places based on data collected by laser range finder (LRF) is achieved through a machine learning approach, which implements logistic regression as a multi-class classifier. The classifier output is probabilistically fused using independent opinion pool strategy. Appealing experimental results are presented based on a data set gathered in various indoor scenarios.

FP6.5 P1091 1720 - 1740
Mobile Sensing and Simultaneously Node Localization in Wireless Sensor Networks for Human Motion Tracking
Sen ZHANG, *Wendong XIAO, **Jun GONG, ***Marcelo H ANG JR, ***Chen Khong THAM, Ronny Quin Fai THAM
This paper exploits optimal position of the mobile sensor to improve the target tracking performance of wireless sensor networks and simultaneously localize both of the static sensor nodes and mobile sensor nodes when tracking the human motion. In our approach, mobile sensors collaborate with static sensors and move optimally to achieve the required detection performance. The accuracy of final tracking result is then improved as the measurements of mobile sensors have higher signal-to-noise ratios after the movement. Specifically, we can simultaneously localize the mobile sensor and static sensors position when localizing the human's position based on augmented extended Kalman filters (EKF). In the algorithm, we develop a sensor movement optimization algorithm that achieves near-optimal system tracking performance. We also presented an sensor nodes management scheme in order to deduce the computation complexity when localizing the static sensor nodes. The effectiveness of our approach is validated by extensive simulations.

Session FP7
Date: Friday, 10 December 2010
Time: 1600 - 1800
Venue: Bluebird

Robot Control II
Chairs: Danwei WANG
Nanyang Technological University

FP7.1 P0268 1600 - 1620
Experimental Investigation of a Path Following Controller for Planar Snake Robots
Pål LILJEBÅCK, *Idar U HAUGSTUEN, *Kristin Y PETTERSEN
SINTEF ICT
*Norwegian University of Science and Technology

This paper considers path following control of snake robots along straight paths. A controller is proposed which, under the assumption that the forward velocity of the snake robot is nonzero and positive, guarantees K-exponential stability of the distance between the snake robot and the desired path and also K-exponential stability of the heading of the robot with respect to the direction of the path. The performance of the path following controller is investigated through experiments with a physical snake robot. The experiments show that the proposed controller successfully steers the snake robot towards and along the desired straight path.

FP7.2 P0515 1620 - 1640
Centrifugal Force Compensation of a Two-Wheeled Balancing Robot
Mishari ALARFAJ, George KANTOR
Carnegie Mellon University

Dynamically balancing, two-wheeled robots with high centers of gravity have been researched over the past few years in order to tackle the restrictions of robots in human environments. These robots are designed to have the same dimensions as humans and be able to actively maintain stability. However these systems are only able to compensate in the fore-aft directions and are limited to slow motions when turning in order to prevent tipping due to centrifugal forces. In this paper we present a two-wheeled balancing robot whose body is an actuated four-bar linkage that can be used to lean. This allows it to control the position of its center of mass in the sideways direction. An overview of the robot concept is presented, and controllers are designed to balance, turn, and lean. Results are presented in dynamic simulation.

FP7.3 P0658 1640 - 1700
Design of Length Measuring System for Stewart Platform using New Forward Kinematics Solution
Hamid REZVANI DASTGERDI, *Mehdi KESHMIRI
Sakht Tajhizate Sepahan - MAPNA Group  
*Isfahan University of Technology

In this paper, based on new presented approach for forward kinematic problem, length measuring system for Stewart platform is designed. The analysis is performed by using a software platform which models the system dynamics and control. A typical feedback linearization method is used to design the controller system and performance of designed controller is studied numerically with respect to measuring error and parametric uncertainties. To provide required parameters for controller, a new forward kinematic solution is designed and compared with Newton-Raphson method numerically. Based on end effector deviations from desired trajectory, actuator length measuring system is compared with moving platform measuring system, which results in more reliable trajectory tracking of controller in case of actuator length measuring system.

**FP7.4 P0662 1700 - 1720**

**Robust Path Following Control of an Unmanned Boat**

*Zhenyu YU*  
Beijing Jiaotong University

Robust path following capability is mandatory for an unmanned boat to perform tasks autonomously. This paper presents a mixed $H_\infty/H_2$ based control which enables the boat to follow paths with connected straight line segments and circular arcs in the absence of yaw angle measurement. The performance of the strategy is evaluated in field test and will be discussed in the paper.

**FP7.5 P0724 1720 - 1740**

**Dual-loop Adaptive Decoupling Control for Single Wheeled Robot - Based on Neural PID Controller**

*Xiaogang RUAN, Qiyuan WANG, Naigong YU*  
Beijing University of Technology

This paper proposes a dual-loop adaptive decoupling control method based on single neuron PID controller (DADC-SNPID), balancing the single wheeled robot. A unique mechanical and control hardware structure of single wheeled robot is designed and its simplified mathematical model is established using the Newton-Euler equations according to the actual parameters of the designed robot. A new balance and motion control method is proposed as dual-loop adaptive decoupling control method based on single neuron PID controller to control the robot. Results of simulation and physical experiments are conducted to illustrate effectiveness of the designed robot system and its controller under certain conditions.

**FP7.6 P0897 1740 - 1800**

**Trajectory Generation of Straightened Knee Walking for Humanoid Robot iCub**

*Zhibin LI, Nikos G TSAGARAKIS, Darwin G*  

*CALDWELL, *Bram VANDERBORGH*  
Italian Institute of Technology, Genova  
*Vrije Universiteit Brussel*

Most humanoid robots walk with bent knees, which particularly requires high motor torques at knees and gives an unnatural looking. It is therefore essential to design a control method that produces a motion which is more energy efficient and natural comparable to those performed by humans. In this paper, we address this issue by modeling the virtual spring-damper based on the cart-table model. This strategy utilizes the preview control, which generates the desired horizontal motion of the center of mass (COM), and the virtual spring-damper for generating the vertical COM motion. The theoretical feasibility of this hybrid strategy is demonstrated in Matlab simulation of a multi-body bipedal model. Knee joint patterns, ground reaction force (GRF) patterns, COM trajectories are presented. The successful walking gaits of the child humanoid "iCub" in the dynamic simulator validate the proposed scheme. The joint torques required by the proposed strategy are reduced, compared with the one required by the cart-table model.
Session FI
Date: Friday, 10 December 2010
Time: 0930 - 1800
Venue: Foyer

Interactive Session III

FI.1 P0378
Adaptive Generalized Minimum Variance Control for TCP/AQM
Roohollah BARZAMINI, Masoud SHAFIEE
Amirkabir University of Technology, Tehran

A new controller AQM strategy for dynamically varying TCP/AQM networks is proposed. Adaptive generalized minimum variance is a combination of online parameter estimations and generalized minimum variance (GMV). The GMV is a suitable control method especially in the presence of measurement noise, but when the process dynamics changes, the controller performance declines. To overcome this problem, the adaptive GMV control approach is recommended. Controller performance was evaluated in two modes, TCP network with unknown parameters and TCP network with time varying parameters. Simulation results indicate that the adaptive GMV AQM (in either case) has been able to keep queue length around the desired point.

FI.2 P0304
Variable Structure Control with Feedforward Compensator for Robot Manipulators subject to Load Uncertainties
Suolin DUAN, Lanping CHEN, Zhenghua MA, Guirong LU
Jiangsu Polytechnic University

A robust control method based on equivalent control of Variable Structure Control (VSC) with feedforward compensator for robotic manipulators subject to load uncertainties is presented. The feedforward compensator is used to improve tracking precision, and the feed-sequence compensator with the Proportional Integral (PI) regulator to the sliding-mode function is used for improving the dynamical performance of sliding mode state in VSC and attenuating the chattering phenomena in conventional sliding-mode state. The experimental results in GR-2 robot manipulators with two degrees of freedom verify the effectiveness of the presented controller.

FI.3 P0385
Robust Coordinated Control of Hot Strip Mill Multivariable System
Kaixiang PENG, Jie DONG
University of Science and Technology Beijing

Hot strip mill is a typical process with high accuracy and high speed. The effective approach to enhance the products competitiveness is to improve the quality and quantity by means of advanced control strategy. A multivariable system comprised of gauge and mass flow of hot strip mill is analyzed in the article. A state-space model about the gauge and mass flow for one stand and inter-stand in a hot strip mill is set up as well. New steady and coordinated control approach on the basis of LQG and H infinite of hot strip mill is proposed and the robust characteristics such as perfect robust stabilization, strong disturbance attenuation and coordination properties are better in the latter. Simulation results show the validity of analysis, design and control.

FI.4 P0775
Nonlinear Sliding Mode Observers for Fault Reconstruction and State Estimations
Kalyana C VELUVOLU, *Yeng Chai SOH
Kyungpook National University
*Nanyang Technological University

In this paper, we shall examine the design of sliding mode observers for Lipschitz nonlinear systems for state and faults/unknown input estimations. The robust terms or the switching terms are designed such that the faults are tracked by their robust terms and so can be reconstructed from the sliding mode. The stability condition for the reduced order system is analyzed and the feedback gain is designed such that the reduced order system is stable. An application example to robotic manipulator is examined to demonstrate the effectiveness of the proposed method in reconstruction of unknown inputs/faults.

FI.5 P0986
Sparse Structured $H_\infty$ Filter Design with for Linear Systems
Wei Wei CHE, Yan-Ping LI
Shenyang University

This paper presents a study on the problem of designing non-fragile $H_\infty$ filters with sparse structure for linear discrete-time systems. The filters to be designed with sparse structure are assumed to be with additive gain variations, which are resulted from filters implementations. Firstly, a class of sparse structures based on the observable standard form is specified from a given fully parameterized $H_\infty$ filter. Then, an LMI-based procedure for designing non-fragile $H_\infty$ filters with the sparse structure is provided. The resulting design guarantees the augmented system asymptotically stable and the $H_\infty$ attenuation level less than a prescribed level. A numerical example is given to illustrate the proposed method.

FI.6 P0493
Robust $H_\infty$ Model Reduction for a Class of Nonlinear Time-varying Systems with Time Delays
Weiwei ZHAO, Xiao HE, Yindong JI
Tsinghua University
In this paper, we are concerned with the $H_{\infty}$ model reduction problem for a class of nonlinear time-varying systems with parameter uncertainties and time delays in a discrete time framework. By introducing a proper Lyapunov function, we establish a sufficient condition ensuring the asymptotically mean square stability of the associate error system with a prescribed $H_{\infty}$ error performance in the form of quasi-linear matrix inequality, based on which the parameters of the reduced-order model can also be determined. Finally, a numerical example is included to show the effectiveness of the developed technique.

**FI.7 P1088**

**Multi-objective Robust PID Controller Tuning using Multi-objective Differential Evolution**


Nanyang Technological University

*Thiagarajar College of Engineering, Madurai

PID controller has been widely applied in engineering area. In this paper, multi-objective differential evolution (MODE) is used to design a multi-objective robust PID controller for two MIMO systems known as distillation column plant and longitudinal control system of the super maneuverable F18/HARV fighter aircraft. Multi-objective robust PID controller problem is formulated by minimizing integral squared error (ISE) and balanced robust performance criteria. The performance of the optimum PID controllers that obtain by MODE is compared with performance reported in literature by other methods in terms of the sum of ISE and balanced robust performance criteria. The results show that the PID controllers obtained by MODE can outperform various optimal PID controllers reported in literature.

**FI.8 P1095**

**Automatic Take-off Control System for Helicopter - An H$_{\infty}$ Approach**


Nanyang Technological University

*Indian Institute of Technology, Delhi

The paper describes the development of an automatic take-off system for helicopter. Design of automatic take-off control system is mandatory for manned as well as unmanned helicopter, which reduce the burden of pilot and increases the flying quality of the vehicle. In this paper, we present an $H_{\infty}$ based automatic take-off system for helicopter. For this purpose, we consider typical four-bladed helicopter with conventional control. A single robust controller for altitude and attitude tracking are designed at single hovering altitude such that controller stabilized the closed loop system at all hovering altitude. The performance of the controller is evaluated in the presence of sensor noise and moderate vertical gust.

**FI.9 P0142**

**Self-learning Continuous Controllers**

Otto Cerman, Petr Husek

Czech Technical University in Prague

In this paper different approach of adaptation mechanism for fuzzy model reference learning control (FMRLC) method will be introduced. In contrast to original method the proposed procedure guarantees continuity of the fuzzy controller that in reward results in its smooth input-output behaviour (mapping) that eliminates undesirable abrupt changes in the control signal. Additionally, the proposed method shows larger robustness to responses of initial conditions and various reference signals. The advantages of the proposed modification are presented on control of magnetic sus-pension system. From result comparing rule bases after adaptation there is absolutely smooth control surface in case of proposed method FMRLC in comparison with original FMRLC. With proposed procedure it was achieved similar result regulation to original FMRLC but with more than 4x smaller adaptation gain.

**FI.10 P0333**

**A Comparative Analysis of LQR and Fuzzy Logic Controller for Active Suspension using Half Car Model**

Faried Hasbullah, Waleed F Faris

International Islamic University Malaysia

The application of the Linear Quadratic Regulator (LQR) and Fuzzy Logic Controller (FLC) in the field of active vibration isolation for a vehicle suspension system is presented and the performances of the two active controllers are compared with the passive system. The performance of the LQR controller is better than the FLC at the expense of control force. The performances of both active controllers are better than the passive system in terms of settling time.

**FI.11 P0488**

**Multidimensional Minimization Training Algorithms for Steam Boiler High Temperature Superheater Trip using Artificial Intelligence Monitoring System**

Firas Basim Ismail, Hussain H Al-Kayiem

University Teknologi PETRONAS

Steam Boilers are important equipment in power plants and the boiler trips may lead to the entire plant shutdown. To maintain performance in normal and safe operation conditions, detecting of the possible boiler trips in critical time is crucial. As a potential solution to these problems, an artificial intelligent monitoring system specialized in boiler high temperature superheater trip has been developed in the present paper. The Broyden Fletcher Goldfarb Shanno (BFGS) and Levenberg-Marquardt (LM) have been
adopted as training algorithms for the developed system. Real site data was captured from MNJ coal-fired thermal power plant-Malaysia. Among three power units in the plant, the boiler high temperature superheater of unit one was considered. An integrated plant data preparation framework for boiler high temperature superheater trip with related operational variables, have been proposed for the training and validation of the developed system. Both one-hidden-layer and two-hidden-layers network architectures are explored using neural network with trial and error approach. The obtained results were analyzed based on the Root Mean Square Error for developed intelligent monitoring system.

**FI.12 P0418**

Integration of INS and GPS using Radial Basis Function Neural Networks for Vehicular Navigation

Malleswaran M, Angel Deborah S, Manjula S, *Vaiidehi VIJAY KUMAR
Anna University, Tirunelveli
*Anna University, Chennai

Navigation systems used in recent days rely mainly on Kalman filter to fuse data from global positioning system (GPS) and the inertial navigation system (INS). In common, INS/GPS data fusion provides reliable navigation solution by overcoming drawbacks such as signal blockage for GPS and increase in position errors with time for INS. Kalman filtering INS/GPS integration techniques used in present days have some inadequacies related to the stochastic error models of inertial sensors, immunity to noise, and observability. This paper aims to introduce a new system integration approach for fusing data from INS and GPS utilizing artificial neural networks (ANN). A multi-layer perceptron ANN has been recently suggested to fuse data from INS and differential GPS (DGPS). Though the integrated system using multi-layer perceptron scheme improves the positioning accuracy, it has shortcomings like complexity with respect to the architecture of multi-layer perceptron networks and limitation of online training algorithm to provide real-time capabilities. This paper, therefore, proposes the use of an alternative ANN architecture. The proposed architecture is based on radial basis function (RBF) neural networks, which generally have simpler architecture and faster training procedures than multi-layer perceptron networks. The RBF-ANN module is trained to predict the INS position error and provide accurate positioning of the moving vehicle.

**FI.13 P0498**

Environmental Monitoring and Air-conditioning Automatic Control with Intelligent Building Wireless Sensor Network

Tao ZHENG, Yajuan QIN, Deyun GAO, Hongke ZHANG
Beijing Jiaotong University

Wireless sensor network (WSN) is the connection between the physical world and mankind. Particularly, environmental monitoring and devices automatic control of intelligent building based on wireless sensor network is considered as one of the most crucial applications. It can perceive many kinds of environmental parameters and feedback control information to some devices to provide comfortable environment to people. However, it is difficult to deploy a WSN in the buildings because there usually are many wireless LAN devices used in the buildings, which bring serious frequency interferences. In this paper, we conduct a real intelligent building wireless sensor network (IBWSN) for environmental monitoring and air-conditioning automatic control. In order to ensure the effectiveness of this system, actual spectrum analysis is developed. Performance evaluation proves that the presented IBWSN can satisfy the needs of the proposed applications.

**FI.14 P1067**

Movement Persuit Control of an Offshore Automated Platform via a RAM-based Neural Network

Horacio L FRANÇA, João Carlos SILVA, *Massimo DE GREGORIO, **Omar LEMBERGE, Max S DUTRA, Felipe M G FRANÇA
Universidade Federal do Rio de Janeiro
*Istituto di Cibernetica - CNR
**Universidad Autónoma de Bucaramanga

The reproduction of the movements of a ship by automated platforms, without the use of sensors providing exact data related to the numeric variables involved, is a non-trivial matter. The creation of an artificial vision system that can follow the cadence of said ship, in six axes of freedom, is the goal of this research. Considering that a real time response is a requisite in this case, it was decided to adopt a Boolean artificial neural network system that could identify and follow arbitrary interest points that could define, as a group, a model of the movement of an observed vessel. This paper describes the development of a prototype based on the Boolean perceptron model WiSARD (Wilkie, Stonham and Aleksander’s Recognition Device), that is being implemented in the C programming language on a desktop computer using a regular webcam as input.

**FI.15 P0125**

Opportunistic 3D Trajectory Generation for the JPL Aerobot with Nonlinear Trajectory Generation Methodology

Weizhong ZHANG, Tamer INANC, *Alberto ELFES
University of Louisville
*California Institute of Technology

NASA is supposed to implement a sustainable and affordable human and robotic program to explore the solar system and beyond as it is the first goal of The President’s Vision for U.S. Space Exploration. The robotic exploration across the solar system consists of exploring Jupiter’s moons, asteroids and other bodies to search for evidence of life, and to understand the
history of the solar system. Trajectory generation for a robotic vehicle is an essential part of the total mission planning. To save energy by exploiting possible situation such as wind will assist a robotic explorer extend its life span and perform tasks more reliably. In this paper, we propose to utilize Nonlinear Trajectory Generation (NTG) methodology to generate 3D opportunistic trajectories for an Aerobot by exploiting wind. The Aerobot is dynamically controlled by three propellers which are respectively parallel to the local three Cartesian axes. Constraints for the Aerobot control are derived from Euler-Lagrange equations since the Aerobot satisfies with the Lagrange-D’Alembert principle. The new proposed Aerobot model takes the aerodynamics into account. The results show that NTG can take the advantage of wind profiles to save significant energy for the defined goal.

FI.16 P0940
Surface-tracking of a 5-DOF Manipulator Equipped with Tactile Sensors
Jingguo WANG, Yangmin LI
University of Macau

Tracking a surface via the end-effector of a manipulator is a tough issue, one not only should implement the position and force control, but also monitor and sense the actual contacting state between the end-effector and the objects surface. In this paper, we present an approach integrating the tactile sensing with force-torque information as the feedback to control the manipulator tracking a surface. Hybrid impedance control method is applied to follow both the position and force trajectories. At the same time, the posture of the end-effector is expected to keep horizontal. With the feedback of tactile sensing data such as contact state, contact area and so on, several strategies of tactile sensing feedback are proposed to be included into the control algorithm. Simulations and two groups of real experiments are made using a 5-DOF manipulator equipped with force/torque and tactile sensors to contact with hard and soft board respectively, and the results are compared and analyzed. The effectiveness of the proposed strategies is validated.

FI.17 P1158
Recurrent Neural Network Based Tracking Control
Zhao XU, Qing SONG, Danwei WANG
Nanyang Technological University

In this paper, a recurrent neural network (RNN) based robust tracking controller is designed for a class of multiple-input-multiple-output (MIMO) discrete time nonlinear systems. The RNN is used in the closed-loop system to estimate online unknown nonlinear system function. A multivariable robust adaptive gradient-descent training algorithm is developed to train RNN. The proposed neural control system guarantees the stability of the closed-loop system and good tracking performance is achieved.

FI.18 P0324
Distributed Control of Mobile Robotic Sensor Networks for Multi-level Barrier Coverage
Teddy M CHENG, Andrey V SAVKIN
The University of New South Wales

We study a problem of K-barrier coverage by employing a network of self-deployed, autonomous mobile robotic sensors. A distributed motion coordination algorithm is proposed for the mobile robotic sensors to address the coverage problem. The algorithm is theoretically developed based on some simple consensus algorithms that only rely on local information. By applying the algorithm to the sensors, K layers of sensor barriers are formed between two given points. To illustrate the proposed algorithm, numerical simulations are carried out for a number of scenarios.

FI.19 P0890
A Distributed Multi-robot Adaptive Sampling Scheme for Complex Field Estimation
Muhammad F MYSOREWALA, *Dan O POPA, Lahouari CHEDED, Mirza Salman BAIG
King Fahd University of Petroleum and Minerals, Dhahran
*The University of Texas at Arlington

Monitoring widespread environmental fields is a complex task that is of great use in many areas, such as building models of natural phenomenon: e.g. moisture in a crop field, oil reservoirs, etc. A successful monitoring of such spatio-temporally distributed fields hinges upon the use of wireless sensor networks which, through their distributed nature, allow for an effective adaptive sampling procedure to gather the statistical information necessary for field density estimation. The adaptive nature of the sampling procedure used embodies a strategy which selects the next sampling location based on the gathered statistical information, and which evolves with past measurements. This paper presents a novel distributed multi-robot "Adaptive sampling algorithm", which is an extension of the algorithm proposed earlier for complex field estimation using a single-robot only. New formulations of sensor fusion in a centralized, decentralized, federated-decentralized, and distributed sensor network are presented for field density estimation, and not just cloud boundary determination. A comparison of the various computational loads involved is included. Simulation results show that adding an efficient partitioning of the sampling area and parallel multi-robot sampling improves the field reconstruction time. With N robots, more than an N-fold reduction in the number of sampling times is observed. The federated and distributed scheme also leads to an improved communication and computational efficiency.
FI.20 P1085
Interacting Multiple Models Based Classification of Moving Objects
Julien BURLET, Olivier AYCARD, Qadeer BAIG
University of Grenoble 1

In this paper, we present an approach performing object behavior classification embedded in a complex and efficient perception method. This method, applied in dynamic outdoor environments using a moving vehicle equipped with a laser scanner, is composed of a local simultaneous localization and mapping (SLAM) with detection and tracking of moving objects (DATMO). While the SLAM is performed by an implementation of incremental scan matching method, the tracking if performed by a Multiple Hypothesis Tracker (MHT) coupled with an adaptive Interacting Multiple Models Filter (IMM). The classification process takes place in the filtering stage and is based on one of the key parameters of the IMM filter which is the Transition Probability Matrix (TPM) modeling objects motion transitions. It permits to automatically classify object behavior and to reuse the classification output to enhance the prediction step in the filtering process. The experimental results on datasets collected from a Daimler Mercedes demonstrator in the framework of the European Project PReVENT-Profusion2 demonstrate the capacity of the proposed algorithm.

FI.21 P0961
Magician Simulator - A Realistic Simulator for Heterogeneous Teams of Autonomous Robots
Adham ATYABI, Tom A F ANDERSON, Kenneth TREHARNE, David M W POWERS
Flinders University

We report on the development of a new simulation environment for use in Multi-Robot Learning, Swarm Robotics, Robot Teaming, Human Factors and Operator Training. The simulator provides a realistic environment for examining methods for localization and navigation, sensor analysis, object identification and tracking, as well as strategy development, interface refinement and operator training (based on various degrees of heterogeneity, robot teaming, and connectivity). The simulation additionally incorporates real-time human-robot interaction and allows hybrid operation with a mix of simulated and real robots and sensor inputs.

FI.22 P0256
An Ensemble Vector Median Filter for Color Image Denoising
Ling ZHONG, Yun ZHANG, Yan XING
Guangdong University of Technology

Focusing on noise reduction in color images, an ensemble-based vector median filter (EVMF) is proposed, which integrates the technique of vector median filtering into the framework of ensemble learning. The algorithm consists of two main steps: 1) Base filtering step, where a contaminated image is filtered by a group of vector median filters (i.e. base filters) in parallel; 2) Meta-filtering step, where the outputs of all the base filters are fed into a vector median filter (i.e. meta-filter) to obtain the final result. The effectiveness performance of EVMF is evaluated and compared with that of several non-ensemble vector median filtering algorithms through the simulation experiment. The experimental results demonstrate that EVMF outperforms the non-ensemble filtering approaches on both noise suppression and detail preservation.

FI.23 P1055
Players Tracking and Ball Detection for an Automatic Tennis Video Annotation
Kosit TEACHABARIKITI, Thanarat H CHALIDABHONGSE, Arit THAMMANO
King Mongkut’s Institute of Technology Latkrabang
*Chulalongkorn University

This paper describes our algorithms for players tracking and ball detection for an automatic broadcast tennis video annotation. The system detects and tracks the players using a robust non-parametric procedure for estimating density gradients called the mean shift algorithm. The basic mean shift tracking algorithm assumes that the target object has separate sufficiently from background, but this assumption is not always true especially when tracking is carried out in dynamic backgrounds such as in sport videos. To cope with this problem, in our proposed system, we embrace the motion segmentation and use the 8x8x8 color histogram to be feature distribution for mean shift tennis players tracking. In order to determine the players’ actions precisely, the system also detect and track ball positions using frame differencing as well as applying some correlation techniques to eliminate false detections. Based on both players’ motion patterns and ball positions, the system can precisely classify the players’ action into backhand ground stroke and forehand ground stroke. Videos of broadcast tennis games downloaded from the Internet have been tested. The results show our system is able to precisely classify the player’s actions with 83.7% precision and 82% recall rates.

FI.24 P1070
HOG Based Multi-Stage Object Detection and Pose Recognition for Service Robot
Li DONG, Xinguo YU, Liyuan LI, Jerry Kah Eng HOE
Institute for Infocomm Research

This paper develops a HOG-based multi-stage approach for object detection and object pose recognition for service robots. This approach makes use of the merits of both multi-class and bi-class HOG-based detectors to form a three-stage algorithm at low computing cost. In the first stage, the multi-class classifier with coarse features is employed to estimate the orientation of a potential target object in the image; in the second stage, a bi-class detector corresponding to the detected orientation with intermediate level features is used to filter out most
of false positives; and in the third stage, a bi-class detector corresponding to the detected orientation using fine features is used to achieve accurate detection with low rate of false positives. The training of multi-class and bi-class SVMs with their respective features in different levels is described. Experiments in real-world environments have shown that the proposed method is much more accurate than the detection method as it uses only multi-class detector. The proposed method is also much more efficient than the detection method as it uses a bi-class detector for each possible orientation. The approach works well on the scenarios where the SIFT-based detector may fail. The method can achieve real-time object detection, localization, and pose recognition on a P4 2.4GHz PC.

**FI.25 P1104**

Full Spectrum Vibration Suppression for Video Stabilization

Wen-Jong LIN, Chuen Leong NG, Hong LUO, ZhongMing GONG, Guilian YANG
Singapore Institute of Manufacturing Technology

Stable and clear video imaging system is crucial in various industry applications for monitoring and remote control purposes. Severe vibrations across full spectrum frequencies are inevitable in many industrial operations resulting in shaky and unclear images. It may reduce the response time for operator and also affect the throughput during the production or monitoring process. On the other hand, commercially available cameras with built-in image stabilization functions may not be sufficient to overcome this problem since they only deal with camera shaking at small magnitude. To stabilize images captured under sever and full spectrum vibration condition, a vibration suppression system was developed. The system consists of a passive vibration mechanism and a digital image stabilization technique. The eddy current damper inside the passive vibration mechanism reduces high frequency vibration, while the digital image stabilization shifts the image for low frequency vibration elimination. Trial results have demonstrated the effectiveness of the system’s capability to cover full vibration spectrum. However, it is also found that it needs to increase the degree-of-freedom (DOF) for this mechanism in the future instead of only single DOF.

**FI.26 P0482**

Eye-Gaze Detection with a Single WebCAM based on Geometry Features Extraction

Nguyen Huu CUONG, *Huynh THAI HOANG
Cantho University

*Ho Chi Minh City University of Technology

In this paper, we propose an efficient approach for real-time eye-gaze detection from images acquired from a web camera. The measured data is sufficient to describe the eye movement, because the web camera is stationary with respect to the head. First, the image is binarized with a dynamic threshold. Then geometry features of the eye image are extracted from binary image. Next using estimation method based on geometry structure of eye, we detect the positions of two eye corners. After that, the center of iris is detected by matching between an iris boundary model and image contours. Finally, using the relative position information between the center of iris and the eye corners, base on the relationship between image coordinate and monitor coordinate, the position where the eye is looking at the monitor is calculated. This system requires only a low cost web camera and a personal computer. Experimental results show that the proposed system can detect accurately eye movements in real-time.

**FI.27 P0601**

Visual Interpretation of Natural Pointing Gestures in 3D Space for Human-Robot Interaction

Zhi LI, Ray JARVIS
Monash University, Melbourne

Visual interpretation of natural pointing gestures is essential in a human robot interaction scenario. Both hands and head are involved in pointing behaviors. Given the color images acquired by a web camera and the depth data by a TOF range camera, we perform visual tracking of the head and hands in 3D space. We investigate both the Head-Finger Line (HFL) and the forearm orientation as the estimation of the pointing direction. HFL is determined by 3D positions of the face and finger tip. Forearm direction is calculated using the PCA method in the RANSAC framework. Their performances are evaluated and compared in the experiments. Face direction and eye gaze orientation provide important cues regarding where the person’s attention is during a pointing operation, which is proven helpful for eliminating some false estimations in our experiment.

**FI.28 P0648**

Liver Cancer Identification based on PSO-SVM Model

Huiyan JIANG, Fengzhen TANG, Xiyou ZHANG
Northeastern University

This paper proposes a novel liver cancer identification method based on PSO-SVM. First, the region of interest (ROI) is determined by Lazy-Snapping, and various texture features are extracted from ROI. Afterwards, F-score algorithm is applied to select relevant features, based on which liver cancer classifier is designed by combining parallel Support Vector Machine (SVM) with Particle Swarm Optimization (PSO) algorithm. PSO is used to automatically choose parameters for SVM, and the advantage is that it makes the choice of parameter more objective and avoids the randomness and subjectivity in the traditional SVM whose parameters are decided through trial and error. The experiment results on real-world datasets show that the proposed parallel PSO-SVM training algorithm improves the prediction accuracy of liver cancer.
Novel Web Cache Architecture
Meenakshi KALIA, Ridhi SOOD
Shobhit University, Meerut

Web cache is a system that is placed between the servers and the clients so as to retrieve the web objects to the clients as quickly as possible. But the algorithms present today are not so efficient to retain the important objects in the web cache. In this paper we analyze several replacement algorithms used in web cache like LFU, LRU and find that sometimes important links are also replaced. Whenever those links are requested again, than that request has to be directed to the server which results in wastage of time. These findings guide us to propose a new underlying architecture over which any of the desired replacement algorithms can be used. Beside replacement factors like recency or frequency used in the replacement we use other factors like Link Rank and Penetration Factor. We divided the web cache into five regions: Mature Region, Young Space, Micro-Cache, Non Popular Object Region and Trash Bin.

Verification of Bank Cheque Images using Hamming Measures
Sankari M, Benazir M, *Bremananth RAMACHANDRAN
Nerhu Institute of Engineering and Technology
*Nanyang Technological University

The main objective of this paper is to verify bank cheques by using account number and account holder’s signature present on the cheque image. Main problem is to exact localization of active regions among non-active contours in the image. Here, we locate the regions based on the prior knowledge of Cartesian coordinate space. It further involves various steps such as Gray-Scale conversion, Segmenting contour, Inner-localization of account number, Feature Extraction and Verification. Gray-scale conversion has been performed on cheque images for reducing dimensionality of cheque size, which are required for further processing. Segmentation and localization are employed together to extract active-regions-of-interests such as account number and signature. Furthermore, segmented account numbers are obtained into individual digits using inner-localization. Feature Extraction is implemented on both account number and signature with trained images using Hamming distance measures (HDM). Finally the verification is processed to identify the matching. Trained and testing features were compared.

A Novel Approach to Remove Redundant Gabor Wavelets for Family Classification
Mohammad GHAHRAMANI, Ngoc Minh DANG, Eam Khwang TEOH, *Wei Yun YAU

Nanyang Technological University
*Institute for Infocomm Research

Gabor Wavelets are widely used to extract facial features since they are robust against illumination and pose changes. Due to the limitation in computational power, the common practice is to down-sample the face image to reduce number of Gabor features generated. As not all of the generated Gabor features are necessary, the main objective of this paper is to develop an efficient removal scheme of redundant filters in order to employ images with large dimension in face data processing. In particular, Genetic Algorithm is used to provide a computational and fast selection of feature ensemble. The base classifiers are trained by the AdaBoost algorithm with the Gabor feature set extracted from each single Gabor filter. By employing the joint diversity, Genetic Algorithm is then applied to select the most discriminate ensemble of classifiers followed by the optimum decision making rule on the classifiers outputs. The proposed approach is implemented in the family classification problem which has large intra-group variation. This method also allows us to select more discriminate filters from higher scales and finer orientations for those families with very young children to improve the performance with the same complexity and calculation load of the conventional Gabor wavelet set.
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WANG Dangxiao
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WANG Huawei
WANG Jian-Gang
WANG Ke
WANG Liangshun
WANG Lichao
WANG Lipo
WANG Lisheng
WANG Lizhen
WANG Rui
WANG Sheng
WANG Shyi-Wen
WANG W
WANG Wei
WANG Weiqun
WANG Xiaofan
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WU Tao
WU Yan
WU Yanhua
WU Zhongcheng

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XI Bin
XIA Linlin
XIAO Gaoxi
XIAO Jing
XIAO Jun
XIAO Lingfei
XIAO Nan
XIAO Qingshan
XIE Xiangsheng
XIE Xiaohu
XIE Xudong
XUE Xiangyang

Y
YAN Fei
YAN Jun
YAN Maode
YAN Zhiguo
YANG Chao
YANG Chao T
YANG Fuzheng
YANG Guohui
YANG Jiu
YANG Ping
YANG Qinghua
YANG Qinwen
YANG Wang
YANG Xiaolong
YANG Yan
YANG Yanhui
YANG Yi
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Z
ZAIKIN Maksim
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<table>
<thead>
<tr>
<th>Name 1</th>
<th>Name 2</th>
<th>Name 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>ZHANG Daming</td>
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</tr>
<tr>
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<td>ZHENG Qi</td>
<td>ZOU Yuan-</td>
</tr>
</tbody>
</table>
# AUTHOR INDEX

<table>
<thead>
<tr>
<th>Author</th>
<th>Schedule</th>
<th>PaperID</th>
</tr>
</thead>
<tbody>
<tr>
<td>A G Salazar-Gonzalez</td>
<td>WA8.5</td>
<td>P0349</td>
</tr>
<tr>
<td>ABASS Ahmed Fahmy</td>
<td>TP3.5</td>
<td>P0673</td>
</tr>
<tr>
<td>ABDEL-RAHEEM Esam</td>
<td>WL.40</td>
<td>P0907</td>
</tr>
<tr>
<td>ABDI Hamid</td>
<td>WL.20</td>
<td>P0621</td>
</tr>
<tr>
<td>ABDULLAH Azizi</td>
<td>TM6.2</td>
<td>P0495</td>
</tr>
<tr>
<td>ABDULLAH Soran Jalal</td>
<td>TA6.1</td>
<td>P0254</td>
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<tr>
<td>ACHTELIK Markus</td>
<td>TI.13</td>
<td>P0517</td>
</tr>
<tr>
<td>ACOSTA CALDERON C A</td>
<td>FM5.1</td>
<td>P0842</td>
</tr>
<tr>
<td>ADAM Alexander</td>
<td>TM6.1</td>
<td>P0351</td>
</tr>
<tr>
<td>ADAMS Martin David</td>
<td>WM6.5</td>
<td>P0908</td>
</tr>
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<td>WA1.2</td>
<td>P1124</td>
</tr>
<tr>
<td>AHMADI Majid</td>
<td>WL.40</td>
<td>P0907</td>
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<td>AHMED Mousumi</td>
<td>FM1.6</td>
<td>P1064</td>
</tr>
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<td>FP5.1</td>
<td>P0687</td>
</tr>
<tr>
<td>AKBARIMAJD Adel</td>
<td>WA7.1</td>
<td>P0509</td>
</tr>
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<td>AKBARIMAJD Adel</td>
<td>WA7.4</td>
<td>P0717</td>
</tr>
<tr>
<td>AKMELIAWATI Rini</td>
<td>TP5.1</td>
<td>P1089</td>
</tr>
<tr>
<td>ALARFAJ Mishari</td>
<td>FP7.2</td>
<td>P0515</td>
</tr>
<tr>
<td>ALBERDI Mikel</td>
<td>WA3.5</td>
<td>P0425</td>
</tr>
<tr>
<td>ALBERTOS Pedro</td>
<td>FM2.6</td>
<td>P1131</td>
</tr>
<tr>
<td>AL-BLUWI Ibrahim</td>
<td>TA3.1</td>
<td>P0342</td>
</tr>
<tr>
<td>ALBOUL Lyuba</td>
<td>FP6.3</td>
<td>P1046</td>
</tr>
<tr>
<td>ALBRECHT Thomas</td>
<td>FM6.3</td>
<td>P0844</td>
</tr>
<tr>
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<td>WA7.2</td>
<td>P0584</td>
</tr>
<tr>
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KONG Jianshou  WI.2  P0340  LI Pu  WP2.1  P0616
KONIGORSKI Ulrich  TI.3  P0453  LI Qian  TI.2  P0389
KOREVAR Agnetha  FA3.3  P0360  LI Shao-yuan  TI.2  P0389
KRISHNA K. Madhava  TA3.4  P0677  LI Wanqing  FA6.4  P0605
KROLL Andreas  WP6.5  P0272  LI Wanqing  TA7.4  P0429
KROOS Christian  FM5.4  P1042  LI Weitao  TM2.6  P0847
KU Chang-Ping  WA8.4  P0881  LI Xiang  FP1.2  P0967
KÜHNLENZ Kolja  TP7.2  P0507  LI Xiang  FP3.6  P0447
KÜHNLENZ Kolja  TP7.6  P0913  LI Xiang  TA6.5  P0587
KULIC Dana  WP4.4  P0825  LI Xiang  TP4.1  P0923
KVARNSTRÖM Jonas  TA5.4  P1155  LI Xiang  TP4.4  P0977
KVARNSTRÖM Jonas  TA5.5  P1156  LI Xiang  TP4.6  P1128
KWEON In So  FM7.2  P0571  LI Xin  TM6.5  P0540
KWON Jeong-Hun  TP7.5  P0688  LI Xingwei  WI.37  P0372
LI Cai  FA6.6  P0586  LI Yan-Ping  WI.2  P0340
LI Chow Yin  FP5.2  P0554  LI Yong-Fu  FA1.6  P0757
LI Wei-Jie  TI.29  P1028  LI Yongmin  WA8.5  P0349
LAM Siew Kei  TI.28  P0845  LI Zhenning  WP4.4  P0825
LAMBERT Alain  WM7.5  P0889  LI Zhi  FI.27  P0601
LATAWIEC Krzysztof J  TP3.3  P1020  LI Zhibin  FP7.6  P0897
LAUGIER Christian  TP6.2  P0511  LIA Alexandre  TP6.3  P0655
LE TRAN Hoai Nam  TM2.2  P0619  LIAN Guofu  FP4.3  P0471
LE Vu Thanh  WM8.1  P0691  LIAN Zhichao  WI.38  P0399
LEE Chong Yee  FA6.6  P0586  LIANG Bin  TI.18  P0851
LEE Dah-Jye  FP2.3  P0623  LIANG Wenfeng  FP5.6  P0857
LEE Dah-Jye  TM6.5  P0540  LILJEBÄCK Pål  FP7.1  P0268
LEE Rim Hee  TI.13  P0517  LILJEBÄCK Pål  WA7.3  P0267
LEE Je Won  TI.14  P0610  LIM Beng Siong  TP4.6  P1128
LEE Jinseok  WL.28  P0692  LIM Chin-heng  WP2.3  P0867
LEE JinSoo  WA8.3  P0944  LIM Hock Beng  WA4.3  P1135
LEE Keon-Ho  TM2.3  P0713  LIM Meng-Hui  TP2.5  P0726
LEE Lai-Kyoung  WM7.1  P0320  LIM Ooi Chong  TI.17  P0782
LEE Lay-Lan  TI.32  P0407  LIM Teck-Yian  TP4.5  P1115
LEE Sang-Deok  TI.22  P0537  LIM Hai  WP4.3  P0483
LEE Sung Joo  TP2.4  P0719  LIM Shin-Yeu  WI.33  P0151
LEE Tae-Kyeong  WP6.3  P0347  LIM Wei  FA3.6  P0736
LEE Tong Heng  FP5.2  P0554  LIM Wei  TA4.2  P1049
LEE Youn Joo  TP2.4  P0719  LIM Wei  WM2.6  P1105
LEES Michael Harold  TM2.2  P0619  LIN Wei  WM5.6  P1026
LEFRANC Pierre  FM1.5  P1032  LIN Wen-Jong  FI.25  P1104
LENG Yu-Chi  FA7.3  P0879  LIN Wen-Jong  WM2.6  P1105
LENGERKE Omar  FL.14  P1067  LIN Zhiping  WA3.4  P1129
LENZ Martin  WA6.5  P0356  LIN Zhiping  WP2.3  P0867
LEOPUTRA Wilson S  FP2.1  P0212  LING Keck Voon  TP4.5  P1115
LEROUX Christophe  TA2.6  P1054  LING Keck Voon  WM2.4  P0850
LEUOTH Sebastian  TM6.1  P0351  LIU Cheng-Ting  TI.29  P1028
LI Ai-Jun  FM1.2  P0258  LIU Chien-Wei  TI.32  P0407
LI Cai  WA1.3  P1137  LIU Chongjie  FA5.4  P0523
LI Cao  FM4.3  P0901  LIU Chongjie  WI.27  P1073
LI Daoping  FM4.2  P0470  LIU Fan  FP3.1  P0983
LI Dawei  TA6.2  P0281  LIU Feng  WM4.1  P0422
LI Dequan  WM3.5  P0529  LIU Gang  TA1.5  P0323
LI Guoqi  WP2.2  P0760  LIU Hao  TI.21  P0943
LI Honghai  FP3.4  P0534  LIU Hong  FM4.3  P0901
LI Hongyi  FA5.5  P0352  LIU Kai  TI.9  P0565
LI Hui  FP4.5  P0925  LIU Lixian  WI.15  P0960
LI Jianxun  FA2.3  P0987  LIU Ning  TA6.4  P0346
LI Jun  FA6.6  P0586  LIU Shuai  TA5.2  P1152
LI Lin  WP3.3  P0600  LIU Wei  WA4.1  P0985
LI Lijuan  FL.24  P1070  LIU Wei  WA4.2  P0994
LI Long  TI.30  P1130  LIU Wenwei  WP3.3  P0600
LI Ning  TI.2  P0389  LIU Xiaohui  WA8.5  P0349
LIU Xiaomeng WP4.3 P0483 MANVI Sunilkumar S WA5.5 P0800
LIU Xinjun FM1.1 P0463 MANZANERA Antoine TA3.3 P0406
LIU Xinzhi FM2.2 P0438 MAO Kezhi TM2.6 P0847
LIU Yi-Hung WI.36 P0179 MAO Pengxuan WA3.2 P0706
LIU Zhitao WP2.1 P0616 MAO Yong TP6.2 P0511
LOH Ai Poh TA7.5 P0548 MAREELS Iven FM5.2 P0981
LOU Lei TP7.6 P0913 MARTIN Adrian WM8.6 P1065
LOVELL Brian C FM6.2 P0946 MARTINET Philippe FA5.2 P1120
LOVELL Brian C FM6.4 P0852 MART MINEZ Alain TP6.6 P0520
LOW Malcolm Yoke Hean TM2.2 P0619 MARTONO Wahyudi TP5.1 P1099
LOW Malcolm Yoke Hean WM5.3 P0737 MASSOL Olivier TP4.1 P0923
LOW Tobias TA3.3 P0406 MASSOL Olivier TP4.6 P1128
LU Chia-Hua WI.9 P0902 MAYER Heinz TA3.2 P0402
LU Dunmin FM5.5 P0759 MATTIOCCIA Stefano TA7.5 P0188
LU Guirong FL.2 P0304 MATVEEV Alexey S TA1.4 P0370
LU Jianhua WM5.4 P0902 MEHMOOD Tahir WI.11 P0753
LU Jiwen WI.39 P0638 MEHMOOD Tahir WI.11 P0753
LU Ningyun WM5.4 P0902 MEHTA Utkal TL7.2 P0709
LU Tien-Fu WI.23 P0577 MENEZ Gerardo M. WI.7 P0361
LU Tien-Fu WM5.2 P0245 MENG Ming FM7.4 P0665
LU Zhe TA4.2 P1049 MENG Wen-Jie FM1.2 P0258
LU Zhe WM5.6 P1026 MENGHEID Kamel TP3.6 P1058
LUCA Anamaria FM1.5 P1032 MIAO Yuan WA5.2 P0744
LUKANISZYN Marian TP3.3 P1020 MIKI Tomohiro WI.3 P0414
LUM Kai Yew TA1.1 P0989 MOGHADAM Peyman TP6.5 P0770
Luo Haibo WA8.1 P0224 MOGHADAM Peyman WP6.1 P0300
Luo Hong FL.25 P1104 MOHAMMAD AIN A H FM7.6 P0945
Luo Hong TA4.2 P1049 MOHAN M Agnes Saranya WM7.6 P0615
Luo Hong WM5.6 P1026 MOHAN Mahesh TA3.4 P0677
Luo Ming TP4.3 P0962 MOHAN Rajesh Elara FM5.1 P0842
Luo Ningsu WM6.1 P0227 MOHD MUSTAFAH Ysir FM6.4 P0852
Luo Yan FM1.1 P0463 MOHD THAN Mohd Nor TL4.2 P0572
Luo Zhizeng FM7.4 P0665 MOONRINTA Jednipat TM2.4 P0731
LUU Khoa WI.41 P1063 MORAS Julien FA5.3 P1150
LY Thanh FM6.3 P0844 MORIGNOT Philippe TA2.6 P1054

M
M Behnam T FA4.2 P0714 MURAKAMI Shigeki FP1.4 P1036
M Benazir FL.30 P0882 MUSOROMY Zwena TA7.2 P1109
M D P Moratuwage TP6.5 P0770 MTLU Ilhan WI.19 P0891
M D P Moratuwage WP6.1 P0300 MYO Maung Thi Rein WM5.2 P0245
M Malleswaran FL.12 P0418 MYSOREWALA M F FI.19 P0890
M Malleswaran TI.12 P0419
M Poornani FP6.6 P0472
M Sankari FL.30 P0882
M Vijayakarthick WA4.5 P0513 N Narayanaswamy WA2.5 P0979
M WILLJUICE I FL.7 P1088 N T Naresh Babu TA7.6 P1127
MA DI WA4.3 P1135 NABATCHIAN Amirhosein WI.40 P0907
MA Li-Shan WM5.5 P0484 NABI Masque Un FI.8 P1095
MA Xueying WI.31 P0394 NAHAVANDI Saeid FA3.1 P0308
MA Zhenghua FL.2 P0304 NAHAVANDI Saeid FA3.5 P0528
MAHINDRAKAR Arun D FA1.1 P0147 NAHAVANDI Saeid FM4.6 P0831
MAHINDRAKAR Arun D FP4.2 P0146 NAHAVANDI Saeid WI.20 P0621
MAINETTI Andrea FA7.5 P0188 NAHAVANDI Saeid WI.22 P0567
MAIRE Frederic FP2.5 P1090 NAHAVANDI Saeid WM8.1 P0691
MAJDI Laila WA7.1 P0509 NAM Joo Hoo TA4.2 P1049
MAJHI Somanath TI.7 P0709 NAM Joo Hoo WM5.6 P1026
MAKINO Harufumi WA8.4 P0881 NAM Yunyoung WI.28 P0692
MAKUR Anamitra WA3.4 P1129 N Sundararajan FM7.5 P0817
MALARTRE Florent TM6.3 P1045 N Sundararajan WA2.5 P0979
MALASHETTY Ravi S WA5.5 P0800 NARUMI Makoto WI.3 P0414
MALIK Arshad WI.11 P0753 NASHASHIBI Fawzi TP6.1 P0502
MALTONI Davide WA1.4 P1146 NASHASHIBI Fawzi TP6.3 P0655
MAN Zhihong TP5.3 P1118 NASIR Adnan TP1.4 P1117
MAN Zhihong TP5.4 P1145 NASUNO Masashi WI.29 P0784
MANOSO Carolina TI.5 P0669 NAYA Yukio WA8.4 P0881

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**ICARCV 2010 PROGRAM OVERVIEW**

*Tuesday, 7 December 2010, 6 pm to 8 pm: Welcome Reception*

*Foyer of Waterfront Ballroom, Level 2*

**Wednesday, 8 December 2010**

A: Automation; C: Control; IS: Invited Session; R: Robotics; V: Vision
## ICARCV 2010 PROGRAM OVERVIEW

**Thursday, 9 December 2010**

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<td>Coffee-Tea with light refreshment, <strong>Foyer, Level 4</strong></td>
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<td>0830 – 0930</td>
<td>Keynote Address 2: Network based Control and Estimation Problems, by Professor Minyue Fu, University of Newcastle, Callaghan, Australia  (<strong>Grand Ballroom, Level 4</strong>)</td>
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<td>0930 – 1000</td>
<td><strong>Morning Tea &amp; Interactive Session, Foyer, Level 4</strong></td>
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<td>1000 – 1200</td>
<td><strong>TA1 (C)</strong> Robust Control I&lt;br&gt;Prof Pierre APKARIAN&lt;br&gt;Dr Philippe Morignot&lt;br&gt;Dr Insu SONG&lt;br&gt;989, 225, 603&lt;br&gt;370, 323, 368  (<strong>Page 63</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA2 (C)</strong> Intelligent Systems&lt;br&gt;Dr K SRIDHARAN&lt;br&gt;Prof Jack Ingoo WANG&lt;br&gt;342, 402, 406&lt;br&gt;677, 1010, 1103  (<strong>Page 64</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA3 (R)</strong> Localization, Navigation and Mapping II&lt;br&gt;Prof Changyun WEN&lt;br&gt;871, 1049, 409&lt;br&gt;596, 700, 754  (<strong>Page 66</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA4 (A)</strong> Instrumentation Systems&lt;br&gt;Prof Patrick DOHERTY&lt;br&gt;1151, 1152, 1154  (<strong>Page 67</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA5 (IS)</strong> Collaborative UAV and UGV Systems&lt;br&gt;Prof Mani Maran RATNAM&lt;br&gt;Dr Yongqiang YE&lt;br&gt;254, 281, 315&lt;br&gt;346, 587, 976  (<strong>Page 69</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA6 (V)</strong> Image/video Analysis I&lt;br&gt;Prof Eric Sung&lt;br&gt;351, 495, 1045&lt;br&gt;1056, 540, 895  (<strong>Page 70</strong>)</td>
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<td>1000 – 1200</td>
<td><strong>TA7 (IS)</strong> Computer Vision &amp; Pattern Recognition&lt;br&gt;Dr Soodamani RAMALINGAM&lt;br&gt;1107, 1109, 1113&lt;br&gt;429, 548, 1127  (<strong>Page 72</strong>)</td>
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<td>1200 – 1310</td>
<td>Lunch, <strong>Waterfront Ballroom, Level 2</strong></td>
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<td>1310 – 1510</td>
<td><strong>Panel Session Control and Autonomy: Challenges and Opportunities</strong>&lt;br&gt;Prof Yeng Chai SOH  (<strong>Page 19</strong>)</td>
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<td>1310 – 1510</td>
<td><strong>TM2 (V)</strong> Feature Extraction, Grouping and Segmentation I&lt;br&gt;Prof Kezhi Mao&lt;br&gt;Dr Andrzej SLUZEK&lt;br&gt;415, 619, 713&lt;br&gt;731, 755, 847  (<strong>Page 74</strong>)</td>
</tr>
<tr>
<td>1310 – 1510</td>
<td><strong>TM6 (V)</strong> Computational Intelligence in Vision&lt;br&gt;Prof Eric Sung&lt;br&gt;351, 495, 1045&lt;br&gt;1056, 540, 895  (<strong>Page 75</strong>)</td>
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<tr>
<td>1510 – 1600</td>
<td>Afternoon Tea &amp; Interactive Session, <strong>Foyer, Level 4</strong></td>
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<td>1600 – 1800</td>
<td><strong>TP1 (4.55pm) (IS)</strong> Sensor Networks&lt;br&gt;Prof Han Lim Choi&lt;br&gt;Dr Wendong Xiao&lt;br&gt;364, 799, 811&lt;br&gt;1117  (<strong>Page 77</strong>)</td>
</tr>
<tr>
<td>1600 – 1800</td>
<td><strong>TP2 (IS)</strong> Advances in Biometric Theory and Applications III&lt;br&gt;Prof Kar Ann Toh&lt;br&gt;Dr Wei Yun Yau&lt;br&gt;798, 1132, 1149&lt;br&gt;719, 726  (<strong>Page 78</strong>)</td>
</tr>
<tr>
<td>1600 – 1800</td>
<td><strong>TP3 (C)</strong> Robust Control II&lt;br&gt;Prof S Janardhanan&lt;br&gt;Prof Krysztof J LATAWIEC&lt;br&gt;380, 386, 1020&lt;br&gt;935, 673, 1058  (<strong>Page 79</strong>)</td>
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<td>1600 – 1800</td>
<td><strong>TP4 (IS)</strong> Intelligent Diagnosis and Prognosis&lt;br&gt;Ms Junhong ZHOU&lt;br&gt;923, 924, 962&lt;br&gt;977, 1115, 1128  (<strong>Page 81</strong>)</td>
</tr>
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<td>1600 – 1800</td>
<td><strong>TP5 (IS)</strong> Variable Structure Control Systems&lt;br&gt;Dr Suiyang KHOO&lt;br&gt;1089, 1099, 1118&lt;br&gt;1145, 1047, 263  (<strong>Page 82</strong>)</td>
</tr>
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<td>1600 – 1800</td>
<td><strong>TP6 (IS)</strong> Autonomy of Vehicular Systems I&lt;br&gt;Prof Christian Lautger&lt;br&gt;Dr Philippe Martinet&lt;br&gt;502, 511, 655&lt;br&gt;684, 770, 520  (<strong>Page 84</strong>)</td>
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<td>1600 – 1800</td>
<td><strong>TP7 (R)</strong> Visual Servoing&lt;br&gt;Prof Wen Chung CHANG&lt;br&gt;Dr Jorge POMARES&lt;br&gt;396, 507, 560&lt;br&gt;611, 688, 913  (<strong>Page 85</strong>)</td>
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<tr>
<td>1900 – 2200</td>
<td>Conference Banquet, <strong>Grand Ballroom, Level 4</strong></td>
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**페이지**

A: Automation; C: Control; IS: Invited Session; R: Robotics; V: Vision
### ICARCV 2010 FINAL PROGRAM OVERVIEW

**Friday, 10 December 2010**

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
<th>Location</th>
<th>Keywords</th>
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<tbody>
<tr>
<td>0800 – 0830</td>
<td>Coffee-Tea with light refreshment, <strong>Foyer, Level 4</strong></td>
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<td>0830 – 0930</td>
<td><strong>Keynote Address 3:</strong> Robots Moving Closer to Humans, by Professor Bruno Siciliano, University of Naples Federico II, Italy (<strong>Grand Ballroom, Level 4</strong>)</td>
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<td>0930 – 1000</td>
<td><strong>Morning Tea &amp; Interactive Session, Foyer, Level 4</strong></td>
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<td>1000 – 1200</td>
<td><strong>FA1 (C): Nonlinear Systems</strong></td>
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<td>Prof Bill GOODWINE</td>
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<td>Prof Maryam DEHGHANI</td>
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<td>231, 278, 757</td>
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<td>1200 – 1310</td>
<td><strong>Lunch, Waterfront Ballroom, Level 2</strong></td>
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<td>1310 – 1510</td>
<td><strong>FM1 (C): Control Applications I</strong></td>
<td><strong>Foyer</strong></td>
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<td>Prof Kirsten Moelgaard NIELSEN</td>
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<td>463, 258, 824</td>
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<td><strong>Afternoon Tea &amp; Interactive Session, Foyer, Level 4</strong></td>
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<td><strong>FP1 (4.5.20pm) (IS): Underwater Robotics</strong></td>
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<td>Dr Norimitsu SAKAGAMI</td>
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<td>Dr Telike TAN</td>
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<td>Prof Meng Joo ER</td>
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<td>Dr Arun D MAHINDRAKAR</td>
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<td>Prof Patricia WONG</td>
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<td>Dr Salim AHMED</td>
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<td>Prof Vaidheel VUAY</td>
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<td>Prof Danwei WANG</td>
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