AUCC
Australian Control Conference
17th-18th November, 2014
Canberra, Australia

Book of Abstracts

ENGINEERS AUSTRALIA

CSS IEEE Control Systems Society

Australian National University
COLLEGE OF ENGINEERING & COMPUTER SCIENCE

ASES
dSPACE

UNSW AUSTRALIA | Canberra

2014 Australian Control Conference
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2014 Australian Control Conference
Canberra, Australia
17-18 November 2014

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Welcome from the AUCC 2014 General Chair

I would like to welcome all of the participants to the 4th Australian Control Conference (AUCC 2014) and to the city of Canberra on behalf of the AUCC 2014 Organising and Technical Program Committees, as well as our main sponsor Engineers Australia.

Since 2011, AUCC has brought together researchers, students and control engineers from industry and Government organisations in the field of control and systems theory providing a forum to present a breadth of research activities and industry practice to a dynamic and varied audience. The conference is organized by Engineers Australia through its National Committee for Automation, Control and Instrumentation (NCACI). It is technically co-sponsored by the IEEE Control Systems Society and this year it is sponsored by the Australian National University and the University of New South Wales, through UNSW Canberra at the Australian Defence Force Academy and my thanks goes to these organisations for their support. I would also like to thank industry sponsors ASES-dSPACE® for their sponsorship of this conference and their support and commitment to the systems and control field in Australia.

I would like to thank all authors for their submissions and for attending and hope that they will find the conference useful and interesting. There were 73 submissions of which 52 were accepted. The conference will feature 2 plenaries, 18 oral presentations (including three papers shortlisted for the best student paper award) and 34 interactive presentations. I hope that you will all find many interesting and exciting ideas on show throughout the conference and enjoy interactions with your colleagues from Australia and overseas, both in the technical sessions and in the social events programmed.

There are many organisations and people that I would like to thank for making the conference a success. Firstly, my thanks to the organising committee, Valery Ugrinovskii, Hemanshu Pota, Jochen Trumpf, Changbin (Brad) Yu, and Robyn Boak who have done all the work that makes the conference a success, and indeed have taken on the bulk of the work since I was overseas for almost the whole organising cycle of the conference. Along with this, my thanks goes to all the academics who have contributed to the conference through reviewing papers and by attending the conference. The scientific quality of the conference is a direct consequence of your commitment and experience. I would like to thank Michael Cantoni (Chair), Ian Manchester, and Daniel Quevedo for their excellent work on the best student paper awards committee. I would also like to thank Dragan Nesic (chair), Brett Ninnes, and again Valery Ugrinovskii for their behind the scenes work on the plagiarism committee. My thanks to the members of the AUCC steering committee, Dragan Nesic, Ian Petersen, Ljubo Vlacic, Matthew James, Reza Moheimani, Mark Pszczel, Victor Sreeram, and Wei Xing Zheng for their support and their confidence and the occasional guiding hand along the way. Finally, it is important not to forget all the ANU and UNSW Canberra students that you have dealt with during registration and in guiding you to the various venues, my thanks to them, and my best wishes for their future careers.

Robert Mahony
AUCC 2014 General Chair

Welcome from the Engineers Australia National Committee on Automation, Control and Instrumentation (NCACI)

Dear AUCC 2014 Participants

On behalf of the Engineers Australia National Committee on Automation, Control and Instrumentation (NCACI), it gives me great pleasure to welcome you to AUCC 2014, the fourth conference of the new Australian Control Conference series.

I hope that you will find AUCC 2014 to be an inspiring and rewarding experience.

I would like to acknowledge the significant effort of the Conference General Chair, Professor Robert Mahony and his team for the planning, preparation and operation of the conference.

I would like to extend our thanks to all committee members and paper reviewers for their hard work, invaluable support and the generosity with which they provided their time and expertise in order to make this conference a success.

Last but not least, thank you conference participants for joining us on this journey. I wish all of you a most rewarding experience at AUCC2014.

I look forward to meeting you now and in many years to come.

Dr Michael J Lees MIEAust CPEng, SMIEEE, RPEQ, NPER
Chair, NCACI

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AUCC 2015
Australian Control Conference

05-06 November 2015, Gold Coast, Australia
http://www.aucc.org.au/AUCC2015/

General Chair:

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Griffith University

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Rahul Sharma
The University of Queensland

Publication Chair:

Michael Lees
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Dzung Dao
Griffith University

Yong Zhu
Griffith University

PhD Student Workshop Chair:

Jahangir Hossain
Griffith University

Web Master:

Ruifeng (Richard) Yan
The University of Queensland

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DSTO

Victor Sreeram
University of Western Australia

Wei Xing Zheng
University of Western Sydney

AUCC Australian Control Conference 5th-6th November, 2015 Gold Coast, Australia

Call for Papers

The 2015 Australian Control Conference (AUCC 2015) will be held on 05-06 November 2015 in the City of Gold Coast at Griffith University Gold Coast campus.
The Australian Control Conference is a conference series that is organised by Engineers Australia through its National Committee for Automation, Control and Instrumentation, NCACI.

AUCC 2015 will provide a forum for Australian researchers, students and control engineers from universities, industry and government organisations to exchange ideas and recent results, as well as discuss current problems arising in control engineering research and industrial practice. International contributions are encouraged and will be solicited for.

Two types of contributions are sought:

- Regular papers:
  - Initial submission: up to 6 pages
  - Final submission: 3 pages (recommended); up to 6 pages (permitted)
- Practitioner papers:
  - Initial submission: an abstract
  - Final submission: 2 pages (recommended); up to 6 pages (permitted)

The proceedings will be available from the Engineers Australia Online Library as well as from IEEE Xplore.

Technical sponsorship is being sought from the IEEE Control Systems Society, IFAC and the Asian Control Association.

Important Dates:

Submission of draft papers:	01 June 2015
Invited Session proposals:	01 June 2015
Workshop & Tutorial proposals:	01 June 2015
Author notification:	31 August 2015
Final papers & Early registration:	28 September 2015
PhD Student Workshop:	04 November 2015
Workshops & Tutorials:	04 November 2015
Conference:	05-06 November 2015

ENGINEERS AUSTRALIA

AUCC 2014 Sponsors

Engineers Australia. Engineers Australia is the national forum for the advancement of engineering and the professional development of our members.

With more than 100,000 members embracing all disciplines of the engineering team, Engineers Australia is the largest and most diverse professional body for engineers in Australia. Our chartered engineers are regarded as trusted professionals not only in Australia, but worldwide. Engineers Australia is steered by a representative body, the National Congress, who elects and monitors the Council of Engineers Australia. There are numerous committees, colleges, technical societies and other groups that actively contribute to the organisation as a whole. Engineers Australia works closely with academic institutions to accredit courses and programs, and ensure they are aligned with international benchmarks.
`http://www.engineersaustralia.org.au/`

IEEE Control Systems Society. The IEEE Control Systems Society is an international scientific, engineering, and professional organization that was founded in 1954 and is dedicated to the advancement of research, development, and practice in automation and control systems. The society and its members are involved in a number of activities, including publishing journals and a magazine, holding a number of conferences, and sponsoring committees in various areas of technical specialization.
`http://ieeecss.org/`

Australian National University. The Australian National University (ANU) was established by an Act of the Federal Parliament in 1946. Its founding mission was to be of enduring significance in the post-war life of the nation, to support the development of national unity and identity, to improve Australia's understanding of itself and its neighbours, and to contribute to economic development and social cohesion.

Today, ANU is a celebrated place of intensive research, education and policy engagement – setting the standard on issues of national and international importance. ANU is a centre of unparalleled intellectual talent and research excellence, a body of students drawn from across the nation and around the world, a leading contributor to public policy formation and debate, a partner to Australia's national government and parliament, and a global university that consistently ranks amongst the world's finest educational institutions.
`http://www.anu.edu.au/`

The University of New South Wales. UNSW Canberra is a campus of UNSW located at the Australian Defence Force Academy in Canberra. UNSW Canberra graduates shape Australia, the region and the international community as leaders in Defence, government, and industry. Working at the intersection of a leading university and a military academy, UNSW Canberra has been educating defence leaders for half a century. Through our experience in education and our achievements in research, we excel in teaching undergraduate, postgraduate and doctoral research students across arts, business, engineering, IT and science. UNSW Canberra is the only Australia's national academic institution with an integrated defence focus with strengths in defence related security and engineering research. UNSW Canberra graduates almost twice as many postgraduate students as undergraduates and our postgraduate programs are accessible by all members of the community.

UNSW Canberra research collaborators include NATO, the US Air Force and US Army Research Office; the Defence Science and Technology Organisation, the Defence Material Organisation, Commonwealth Scientific and Industrial Research Organisation, the Australian Nuclear Science and Technology Organisation and the Department of Veteran Affairs.
`http://www.unsw.adfa.edu.au/`

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`http://www.ases.com.au/`

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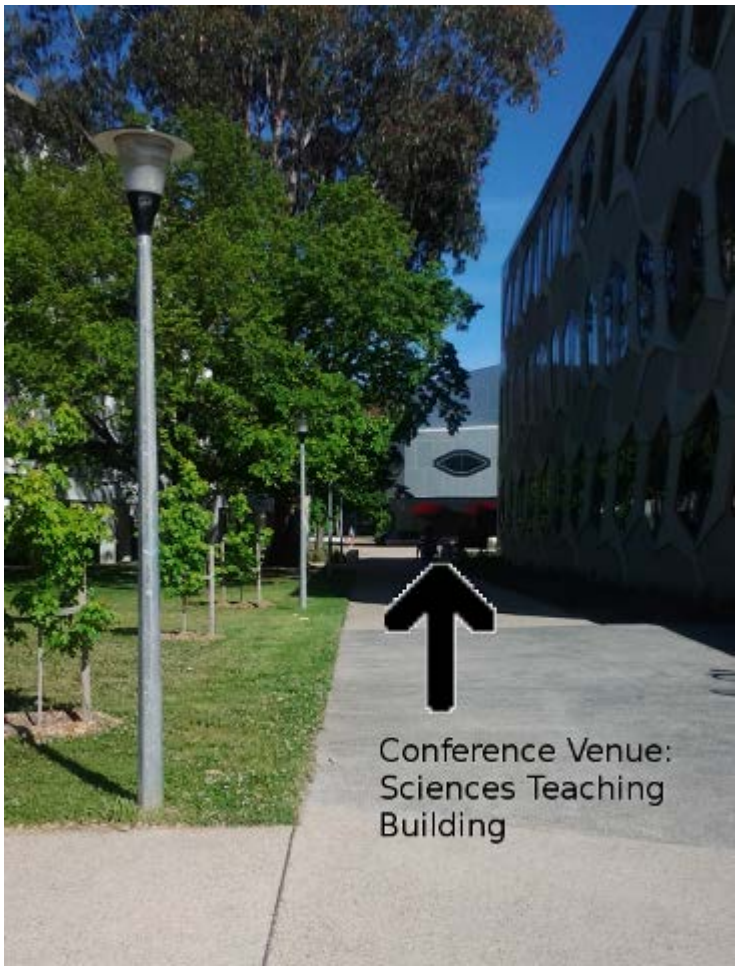
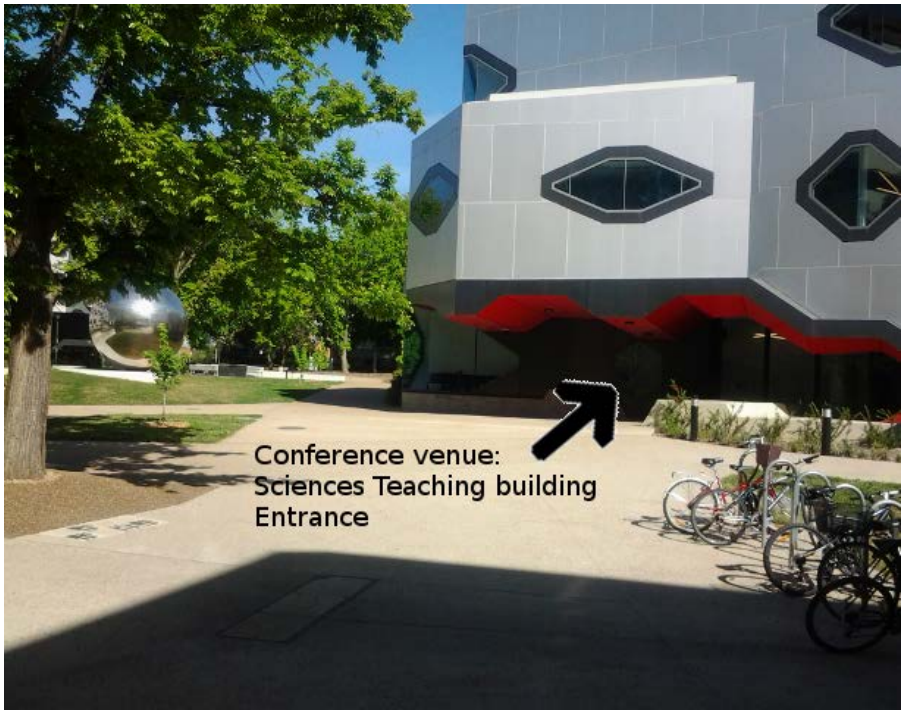
2014 Australian Control Conference
Conference Information



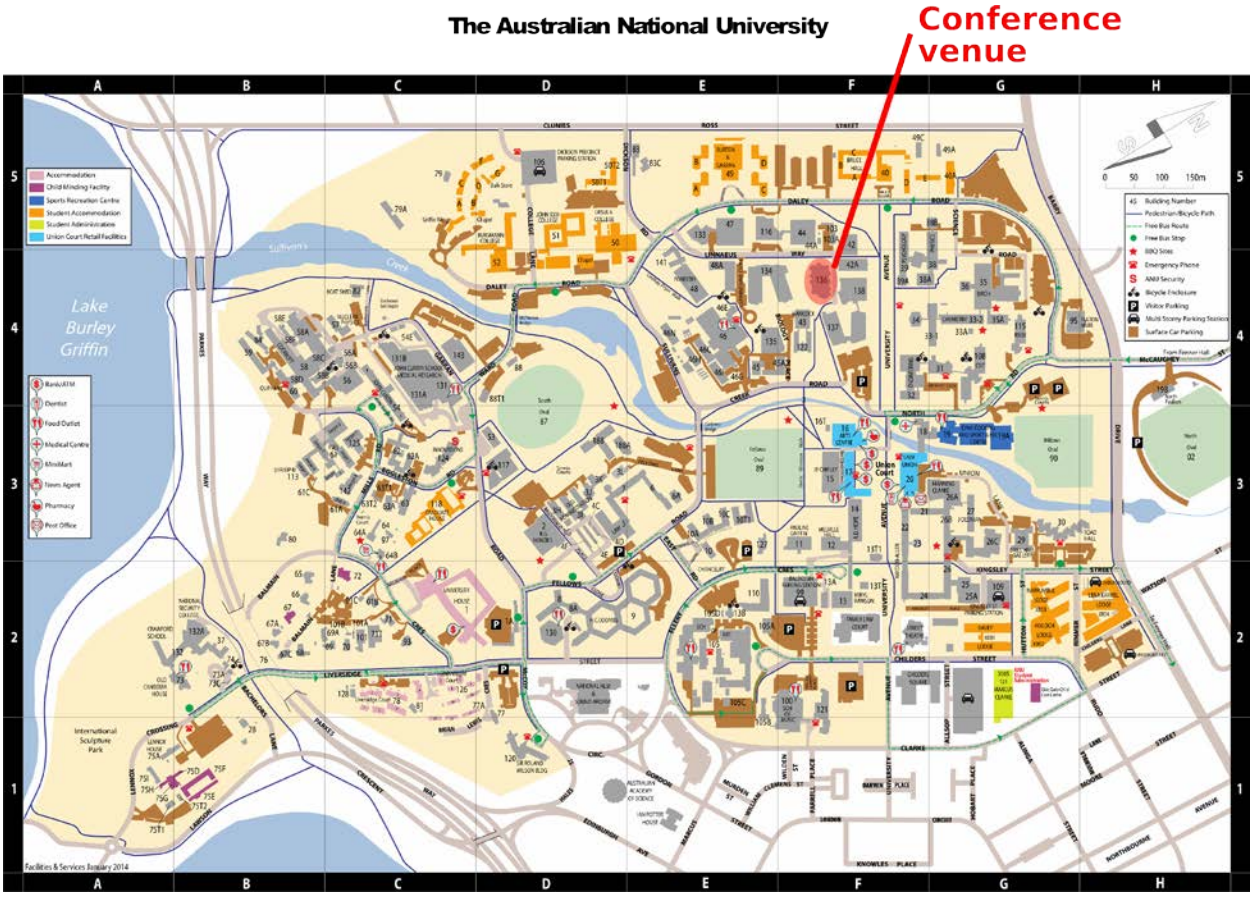
The conference venue approaching from the East (looking West).



Building entrance

Conference information

Conference venue: The 2014 Australian Control Conference (AUCC 2014) will be held at the Sciences Teaching Building, Bldg. #136, Acton Campus, Australian National University, Canberra. The location of the conference venue is shown on the map below. An online version and a printable pdf copy of the map are available at `http://campusmap.anu.edu.au/largemap.asp`



Getting there: The conference venue is most easily reached on foot from central Canberra (Civic). Cars are allowed on campus, however, parking is heavily restricted (see the above map for visitor parking locations) and very expensive. Most on campus parking is restricted to a maximum of 3 hours. We strongly encourage conference delegates to make alternative arrangements. More information can be found here: `http://facilities.anu.edu.au/services/transport?pid=2`

On-site registration: Conference delegates will receive their name badges, conference materials and social event tickets (including any additional tickets) at the registration desk on Level 3 of the conference venue. Participants are kindly requested to wear their name badges during all conference events.

Registration fees	
Full registration fee	AUD $550
Student registration fee	AUD $400

Registration desk opening hours	
Monday 17 November	08:00-17:00
Tuesday 18 November	08:00-11:00

All students registering for the conference must have been enrolled at a recognised university in a relevant technical degree at a level equivalent to at least half time during the preceding 12 months to the conference. That is, at least half time for the full academic year of 2014, or full time during the first semester 2014.

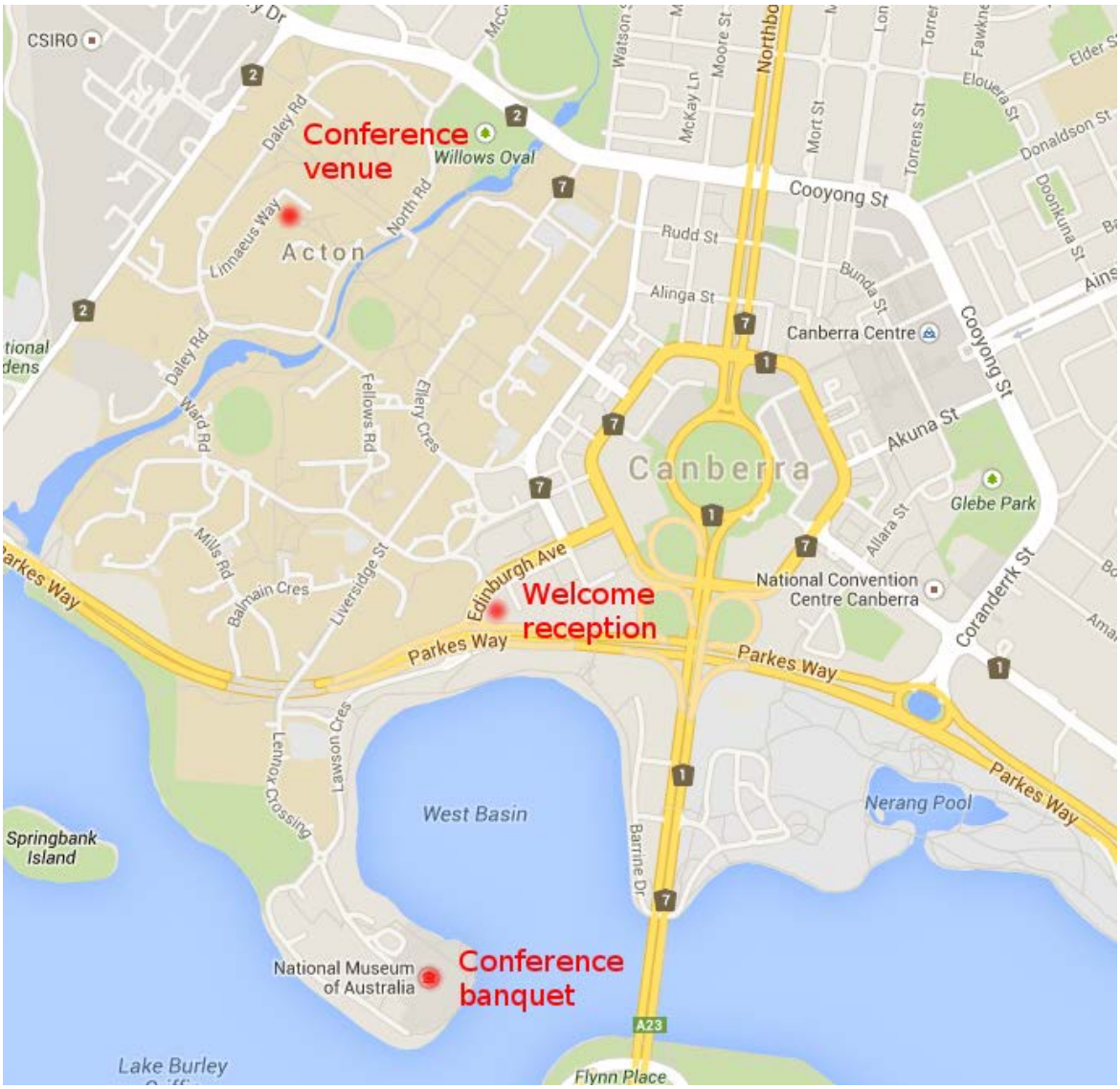
Coffee breaks and lunch: Tea, coffee and light refreshments during the scheduled coffee breaks are included in the registration fee. Lunch is provided free of charge for all conference delegates on both days of the conference.

Social events:

Welcome reception
Date: Sunday November 16, 2014
Time: 17:00 – 19:00
Venue: Mosaic Room @ Nishi, 25 Edinburgh Ave, New Acton, Canberra
`http://www.hotel-hotel.com.au/conferencing-venues/`

Conference banquet
Date: Monday November 17, 2014
Time: starts 18:30
Venue: National Museum of Australia, Lawson Crescent, Acton Peninsula, Canberra
`http://www.nma.gov.au/`

Conference delegates are invited to join a group walking from the conference venue to the banquet venue (2.2 km through pleasant parkland) directly after close of sessions on Monday, transport by group taxi will be organised on request.



2014 Australian Control Conference
Technical Program

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AUCC 2014 Program Sunday November 16, 2014
17:00-19:00 Welcome reception Mosaic room @ Nishi, 25 Edinburgh Ave

AUCC 2014 Program Monday November 17, 2014	
08:30-08:40 MoOP Welcome from the AUCC 2014 General Chair	STB S1
08:40-09:40 MoAP Student Best Papers	STB S1
09:40-10:05 MoBEP Elevator Pitch for Interactive Session I	STB S1
10:05-11:10 MoBI1 Interactive Session I & Coffee break	STB S2
11:10-12:30 MoCP Control and Estimation of Quantum Systems	STB S1
12:30-14:00 Lunch break (lunch provided)	STB S2
14:00-15:20 MoDP Control Applications	STB S1
15:20-15:45 MoEEP Elevator Pitch for Interactive Session II	STB S1
15:45-17:00 MoEI1 Interactive Session II & Coffee break	STB S2
17:00-18:00 MoPP Plenary Lecture 1	STB S1

18:30 Conference banquet National Museum of Australia

AUCC 2014 Program Tuesday November 18, 2014	
08:30-09:30 TuPP Plenary Lecture 2	STB S1
09:30-09:55 TuAEP Elevator Pitch for Interactive Session III	STB S1
09:55-11:00 TuAI1 Interactive Session III & Coffee break	STB S2
11:00-12:20 TuBP Nonlinear/Robust/Model Predictive Control	STB S1
12:20-13:45 Lunch break (lunch provided)	STB S2
13:45-14:10 TuCEP Elevator Pitch for Interactive Session IV	STB S1
14:10-15:10 TuCI1 Interactive Session IV & Coffee break	STB S2
15:10-16:10 TuDP Estimation	STB S1

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AUCC 2014 Best student paper award

The AUCC Best student paper award recognises excellence in a paper presented at an Australian Control Conference whose primary author is a student. As part of a greater commitment to promoting, encouraging and training future engineers in Australia, the prize for the best student paper is sponsored by Engineers Australia. The award consists of a certificate and a cheque for AUD $500. Runner ups will be awarded a certificate only.

Ten papers were nominated for the AUCC 2014 Best student paper award. The awards committee chaired by Michael Cantoni (Univ. of Melbourne) and formed by himself, Ian Manchester (Univ. of Sydney) and Daniel Quevedo (Univ. of Newcastle) shortlisted three papers. They are:

- Finalist: **Zhiyong Sun** (Autralian National Univ.)
  Nominator: Brian D.O. Anderson
  Paper title: Convergence Analysis for Rigid Formation Control with Unrealizable Shapes: The 3 Agent Case
  Authors: Zhiyong Sun, Shaoshuai Mou, Uwe R. Helmke, and Brian D.O. Anderson

- Finalist: **Rahmat Heidari** (Univ. of Newcastle)
  Nominator: Julio H. Braslavsky
  Paper title: Ultimate Boundedness of Droop Controlled Microgrids with Secondary Loops
  Authors: Rahmat Heidari, Maria M. Seron, and Julio H. Braslavsky

- Finalist: **Shogo Takada** (Kanazawa Univ.)
  Nominator: Osamu Kaneko
  Paper title: Data-Driven Tuning of Nonlinear Internal Model Controllers for Pneumatic Artificial Muscles
  Authors: Shogo Takada, Osamu Kaneko, Taiki Nakamura, and Shigeru Yamamoto

The shortlisted papers will be presented by the finalists in the first technical session of the conference, **MoAP, Monday November 17, 08:40-09:40, STB S1**. The awards committee will base their final decision on both the paper and the oral presentation. The winner will be announced at the conference banquet.

AUCC 2014 Plenary lecture

MoPP.1, Monday November 17, 17:00-18:00, STB S1
High-Speed Atomic Force Microscopy: Mechatronic Design and Control Challenges

The Atomic Force Microscope (AFM) is one of the most remarkable scientific instruments to emerge out of the 20th century. Imaging in 3D with atomic resolution is one of the most unique features of the AFM. Unlike traditional light and scanning electron microscopes (SEMs) which create images of matter by measuring the intensity of reflected electromagnetic radiation, the sharp tip of an AFM micro-probe reacts to the sample surface and thus the AFM creates images by mechanically “feeling” the surface with the micro-probe. While the resolution of light microscopy is limited by the refraction of visible light, and SEMs on the diffraction of electron beams, the resolution of the AFM is directly related to the precision and accuracy of positioning the AFM probe relative to a sample surface. Additionally, the throughput of the AFM is limited by how fast the probe can be positioned over the specimen. Increasing the throughput of an AFM while maintaining its high accuracy amounts to a significant challenge. This talk reports on recent efforts to develop video-rate atomic force microscopes for direct observation of dynamic processes at extremely high resolutions by combining innovative mechatronic design and high-performance control.

S.O. Reza Moheimani received the Doctoral degree from the University of New South Wales at the Australian Defence Force Academy in Canberra, Australia, in 1996. He joined the University of Newcastle in 1997embarking on a new research program addressing the dynamics and control design issues related to high-precision mechatronic systems. He is the founder and director of the Laboratory for Dynamics and Control of Nanosystems, a multimillion-dollar state-of-the-art research facility. He has published over 300 refereed papers and five books and edited volumes. His current research interests include ultra-high-precision mechatronic systems, with particular emphasis on dynamics and control at the nanometer scale, including applications of control and estimation in nanopositioning systems for high-speed scanning probe microscopy, modeling and control of microcantilever-based devices, control of micro-actuators in microelectromechanical systems, and design, modeling and control of micro-machined nanopositioners for on-chip atomic force microscopy.

Professor Moheimani is a fellow of IEEE, IFAC and the Institute of Physics, U.K. His work has been recognized with a number of awards, including the IFAC Nathaniel B. Nichols Medal in 2014, the IFAC Mechatronic Systems Award in 2013, the IEEE Control Systems Technology Award in 2009, the Australian Research Council Future Fellowship in 2009, the IEEE Transactions on Control Systems Technology Outstanding Paper Award in 2007, the Australian Research Council Post Doctoral Fellowship in 1999, and several best student paper awards in various conferences. He has served on the editorial boards of a number of journals, including IEEE/ASME Transactions on Mechatronics, IEEE Transactions on Control Systems Technology, and Control Engineering Practice. He currently chairs the IFAC Technical Committee on Mechatronic Systems, and has chaired several international conferences and workshops.

AUCC 2014 Plenary lecture

TuPP.1, Tuesday November 18, 08:30-09:30, STB S1
A Theory of Information for Nonstochastic Estimation and Control

Shannon's probabilistic concept of information is a central tool for delineating fundamental performance limits in communication systems. With the advent of networked control systems, information has also gained renewed appreciation as a concept in control theory, and it is now understood that stochastic control performance is related to the amount of information flowing in the feedback loop. However, unlike in communications, disturbances in control are often modelled as deterministic unknowns with bounded magnitude or power. In such systems, Shannon's original probabilistic framework is inapplicable. This raises the question of whether it is possible to construct useful analogues of independence, Markovness and information for estimation and control, without having to assume a statistical model. This talk describes a recent framework for doing so, leading to the construction of nonstochastic versions of information and directed information. It is shown that the largest nonstochastic information rate through an error-prone channel coincides exactly with its operational zero-error capacity and, similarly, that the largest nonstochastic directed information yields the operational zero-error feedback capacity. These results lead to tight conditions for estimating or controlling the state of a linear system over an erroneous communication channel, under the requirement of bounded estimation errors or states. The extension to multi-agent systems is then discussed.

Girish N. Nair was born in Malaysia and obtained a B.Engineering (Elec., 1st class Hons.) in 1994, B.Science (math.) in 1995, and Ph.D. (elec. eng.) in 2000, on scholarships from the Australian government and the University of Melbourne. He is a professor in the Department of Electrical and Electronic Engineering at the University of Melbourne since 2014, and has previously held visiting positions at the University of Padova (2005), Boston University (2005), and ETH Zürich (2013). His research interests lie in information theory and networked control, and his work has received several prizes, including a SIAM Outstanding Paper Prize in 2006, and the Best Theory Paper Prize at the UKACC International Conference on Control, Cambridge University, 2000. He was an associate editor for the SIAM Journal on Control and Optimization from 2006 - 2011, and has been an associate editor for the IEEE Transactions on Automatic Control since 2011.

MoAP STB S1

Student Best Papers (Regular Session)

Chair: Cantoni, Michael — Univ. of Melbourne
Co-Chair: Quevedo, Daniel E. — Univ. of Newcastle

08:40-09:00 MoAP.1

Convergence Analysis for Rigid Formation Control with Unrealizable Shapes: The 3 Agent Case, pp. 1-6.

Sun, Zhiyong — Australian National Univ
Mou, Shaoshuai — Yale Univ
Helmke, Uwe R. — Univ. of Wuerzburg
Anderson, Brian D.O. — Australian National Univ

09:00-09:20 MoAP.2

Ultimate Boundedness of Droop Controlled Microgrids with Secondary Loops, pp. 7-12.

Heidari, Rahmat — Univ. of Newcastle
Seron, Maria M. — Univ. of Newcastle
Braslavsky, Julio H. — Commonwealth Scientific and Industrial Res. Organisation

09:20-09:40 MoAP.3

Data-Driven Tuning of Nonlinear Internal Model Controllers for Pneumatic Artificial Muscles, pp. 13-18.

Takada, Shogo — Kanazawa Univ
Kaneko, Osamu — Kanazawa Univ
Nakamura, Taiki — Kanazawa Univ
Yamamoto, Shigeru — Kanazawa Univ

MoBI1 STB S2

Interactive Session I (Interactive Session)

Chair: Mahony, Robert — Australian National Univ.
Co-Chair: Nurdin, Hendra Ishwara — Univ. of New South Wales

10:05-11:10 MoBI1.1

Max-Plus Fundamental Solution Semigroups for Dual Operator Differential Riccati Equations, pp. 19-24.

Dower, Peter M. — Univ. of Melbourne
McEneaney, William — Univ. of California San Diego

10:05-11:10 MoBI1.2

A Popov Approach to Performance Analysis and Coherent Guaranteed Cost Control for Uncertain Quantum Systems, pp. 25-30.

Xiang, Chengdi — UNSW Canberra at the Australian Defence Force Acad
Petersen, Ian R. — Australian Defence Force Acad
Dong, Daoyi — Univ. of New South Wales

10:05-11:10 MoBI1.3

UAV Control on the Basis of Bearing-Only Observations, pp. 31-36.

Miller, Alexander — Inst. for Information Transmission Problems, RAS
Miller, Boris — Monash Univ

10:05-11:10 MoBI1.5

Control of a River Stretch with Uncertain Inflows, pp. 37-42.

Nasir, Hasan Arshad — Univ. of Melbourne
Weyer, Erik — Univ. of Melbourne

10:05-11:10 MoBI1.6

Effective Wind Speed Estimation and Optimized Setting Strategy for WTGS Based on SCADA System, pp. 43-48.

Hu, Yang — North China Electric Power Univ
Liu, Jizhen — North China ElectricPower Univ
Chang, Taihua — North China Electric Power Univ
Li, Wei — North China Electric Power Univ
Lin, Zhongwei — Beihang Univ
Meng, Hongmin — North China Electric Power Univ

10:05-11:10 MoBI1.7

Coordinated Control of Once-Through Boiler-Turbine Units Using Feedforward-Feedback Approach Based on Stable Inversion, pp. 49-54.

Li, Lu — North China Electric Power Univ
Zeng, Deliang — North China Electric Power Univ
Chang, Taihua — North China Electric Power Univ
Lv, You — North China Electric Power Univ

10:05-11:10 MoBI1.8

Computational Complexity of Robust Schur Stability Analysis by the Generalized Stability Feeler, pp. 55-59.

Matsuda, Tadasuke — Tokyo Univ. of Science
Matsui, Hajime — Toyota Tech. Inst
Kawanishi, Michihiro — Toyota Tech. Inst
Narikiyo, Tatsuo — Toyota Tech. Inst

10:05-11:10 MoBI1.9

Short-Data Recursive HMM Parameter Estimation for Rapid Vision-Based Aircraft Heading Estimation, pp. 60-65.

Molloy, Timothy Liam — Queensland Univ. of Tech
Ford, Jason — Queensland Univ. of Tech

MoCP STB S1

Control and Estimation of Quantum Systems (Regular Session)

Chair: James, Matthew R. — Australian National Univ.
Co-Chair: Dong, Daoyi — Univ. of New South Wales

11:10-11:30 MoCP.1

End-To-End Entanglement in a Coherent Feedback Interconnection of Three Nondegenerate Optical Parametric Amplifiers, pp. 66-71.

Shi, Zhan — Univ. of New South Wales
Nurdin, Hendra Ishwara — Univ. of New South Wales

11:30-11:50 MoCP.2

A Direct Coupling Coherent Quantum Observer for a Single Qubit Finite Level Quantum System, pp. 72-76.

Petersen, Ian R. — Australian Defence Force Acad

11:50-12:10 MoCP.3

Synchronisation of Micro-Mechanical Oscillators Inside One Cavity Using Feedback Control, pp. 77-82.

Miao, Zibo — Australian National Univ
Hosseini, Mahdi — Massachusetts Inst. of Tech
Guccione, Giovanni — Australian National Univ
James, Matthew R. — Australian National Univ

12:10-12:30 MoCP.4

Robust Mean Square Stability of Open Quantum Stochastic Systems with Hamiltonian Perturbations in a Weyl Quantization Form, pp. 83-88.

Khodaparastsichani, Arash — UNSW Canberra at the Australian Defence Force Acad
Vladimirov, Igor — UNSW Canberra
Petersen, Ian R. — Australian Defence Force Acad

MoDP	STB S1
Control Applications (Regular Session)	
Chair: Manchester, Ian R.	Univ. of Sydney
Co-Chair: Dower, Peter M.	Univ. of Melbourne
14:00-14:20	MoDP.1
Vulnerability Analysis of Large-Scale Dynamical Networks to Coordinated Attacks, pp. 89-94.	
Nandanoori, Sai Pushpak	Iowa State Univ
Diwadkar, Amit	Iowa State Univ
Vaidya, Umesh	Iowa State Univ
Fardad, Makan	Syracuse Univ
14:20-14:40	MoDP.2
Hot-Start Efficiency of Quadratic Programming Algorithms for Fast Model Predictive Control: A Comparison Via an Adaptive Optics Case Study, pp. 95-100.	
Konnik, Mikhail	Univ. of Newcastle
De Dona, Jose	Univ. of Newcastle
14:40-15:00	MoDP.3
Geoengineering Via Solar Radiation Management As a Feedback Control Problem: Controller Design for Disturbance Rejection, pp. 101-106.	
Weller, Steven	Univ. of Newcastle
Schulz, Brenton	Univ. of Newcastle
15:00-15:20	MoDP.4
Time Weighted Model Reduction of Flat Plate Solar Collectors, pp. 107-111.	
Jazlan, Ahmad	Univ. of Western Australia
Sreeram, Victor	Univ. of Western Australia
Togneri, Roberto	Univ. of Western Australia
Bettayeb, Maamar	Univ. of Sharjah

MoEI1	STB S2
Interactive Session II (Interactive Session)	
Chair: Trumpf, Jochen	Australian National Univ.
Co-Chair: De Dona, Jose	Univ. of Newcastle
15:45-17:00	MoEI1.1
A New Non-Iterative Solution for a Class of Difference Riccati Equations, pp. 112-117.	
Zhang, Huan	Univ. of Melbourne
Dower, Peter M.	Univ. of Melbourne
15:45-17:00	MoEI1.2
A Quantum Mechanical Version of Price's Theorem for Gaussian States, pp. 118-123.	
Vladimirov, Igor	UNSW Canberra
15:45-17:00	MoEI1.3
Approximate Bang-Bang Lyapunov Control for Closed Quantum Systems, pp. 124-129.	
Kuang, Sen	Univ. of Science and Tech. of China
Dong, Daoyi	Univ. of New South Wales
Petersen, Ian R.	Australian Defence Force Acad
15:45-17:00	MoEI1.4
Negative Imaginary Feedback Systems, pp. 130-133.	
Mabrok, Mohamed	UNSW Canberra at the Australian Defence Force Acad
Petersen, Ian R.	Australian Defence Force Acad
15:45-17:00	MoEI1.5
Finite-Horizon H-Infinity Control for a Class of Time-Varying Nonlinear Systems Subject to Sensor and Actuator Saturations, pp. 134-139.	
Wei, Yunliang	Nanjing Univ. of Science and Tech
Zheng, Wei Xing	Univ. of Western Sydney
15:45-17:00	MoEI1.6
Inversion Formulae for the Design of PIDF Controllers, pp. 140-145.	
Cuoghi, Stefania	Univ. of Modena and Reggio Emilia
Ntogramatzidis, Lorenzo	Curtin Univ
15:45-17:00	MoEI1.7
Distributed Consensus of Linear Multi-Agent Systems with Switching Directed Topologies, pp. 146-151.	
Wen, Guanghui	Southeast Univ
Ugrinovskii, Valery	Univ. of New South Wales
15:45-17:00	MoEI1.9
Passivity-Based Adaptive Control for Visually Servoed Robotic Systems, pp. 152-157.	
Wang, Hanlei	Beijing Inst. of Control Engineering

MoPP	STB S1
Plenary Lecture 1 (Plenary Session)	
Chair: Ugrinovskii, Valery	Univ. of New South Wales
17:00-18:00	MoPP.1
*High-Speed Atomic Force Microscopy: Mechatronic Design and Control Challenges**.	
Moheimani, S.O. Reza	Univ. of Newcastle

Technical Program for Tuesday November 18, 2014

TuPP	STB S1
Plenary Lecture 2 (Plenary Session)	
Chair: Mahony, Robert	Australian National Univ.
08:30-09:30	TuPP.1
*A Theory of Information for Nonstochastic Estimation and Control**.	
Nair, Girish N.	Univ. of Melbourne

TuAI1	STB S2
Interactive Session III (Interactive Session)	
Chair: Kellett, Chris	Univ. of Newcastle
Co-Chair: Zheng, Wei Xing	Univ. of Western Sydney
09:55-11:00	TuAI1.1
Model Validation and Set Membership State Estimation for Continuous-Time Nonlinear Systems: Contraction Metric Approach, pp. 158-163.	
Ouyang, Hua	Univ. of New South Wales
Manchester, Ian R.	Univ. of Sydney
09:55-11:00	TuAI1.2
An Investigation of Set-Theoretic Methods for Fault Detection in Lure Systems, pp. 164-169.	
Hanafi, Ainain Nur	Univ. of Newcastle
Seron, Maria M.	Univ. of Newcastle
De Dona, Jose	Univ. of Newcastle

09:55-11:00 TuAI1.3

On a New Uniform Dynamic Coding Algorithm for Model-Based Networked Control Systems, pp. 170-175.

Wang, Gexia	Shanghai Univ. of Electric Power
Tan, Ying	Univ. of Melbourne
Mareels, Iven	Univ. of Melbourne

09:55-11:00 TuAI1.4

Pruning Error Analysis for a Class of Curse-Of-Dimensionality Free Methods, pp. 176-181.

Zhang, Huan	Univ. of Melbourne
Dower, Peter M.	Univ. of Melbourne

09:55-11:00 TuAI1.5

Model Predictive Control of Differentially Flat Systems Using Haar Wavelets, pp. 182-187.

Wang, Ruigang	Univ. of New South Wales
Tippett, Michael James	Univ. of New South Wales
Bao, Jie	Univ. of New South Wales

09:55-11:00 TuAI1.6

Detectability of Distributed Consensus-Based Observer Networks: An Elementary Analysis and Extensions, pp. 188-192.

Ugrinovskii, Valery	Univ. of New South Wales

09:55-11:00 TuAI1.7

Further Results on a Class of Nonlinear Protocols in Networked Systems, pp. 193-198.

Emadi, Hamid	Iowa State Univ
Srivastava, Vaibhav	Princeton Univ
Vaidya, Umesh	Iowa State Univ
Bhattacharya, Sourabh	Iowa State Univ

09:55-11:00 TuAI1.8

Gain Scheduling Control for Magnetic Levitation Device Using Redundant Descriptor Representation, pp. 199-204.

Kumada, Tatsuro	Nanzan Univ
Chen, Gan	Nanzan Univ
Takami, Isao	Nanzan Univ

09:55-11:00 TuAI1.9

Robustness of the Characteristic Model-Based Golden-Section Adaptive Control, pp. 205-210.

Huang, Huang	Beijing Inst. of Control Engineering

TuBP STB S1

Nonlinear/Robust/Model Predictive Control (Regular Session)

Chair: Nesic, Dragan	Univ. of Melbourne
Co-Chair: Ntogramatzidis, Lorenzo	Curtin Univ.

11:00-11:20 TuBP.1

Frequency-Domain Stability Criteria for Distributed-Parameter Systems under Periodic Sampled-Data Feedback Control, pp. 211-214.

Kao, Chung-Yao	National Sun Yat-Sen Univ
Cantoni, Michael	Univ. of Melbourne

11:20-11:40 TuBP.2

Output-Feedback Control of Nonlinear Systems Using Control Contraction Metrics and Convex Optimization, pp. 215-220.

Manchester, Ian R.	Univ. of Sydney
Slotine, Jean-Jacques E.	Massachusetts Inst. of Tech

11:40-12:00 TuBP.3

Offset-Free Output Feedback Predictive Control for Longitudinal Beam Dynamics in Heavy Ion Synchrotrons, pp. 221-226.

Faulwasser, Timm	Ec. Pol. Fédérale De Lausanne
Lens, Dieter	TU Darmstadt
Kellett, Chris	Univ. of Newcastle

12:00-12:20 TuBP.4

Nonlinear L2-Gain Verification for Bilinear Systems, pp. 227-232.

Dower, Peter M.	Univ. of Melbourne
Kellett, Chris	Univ. of Newcastle

TuCI1 STB S2

Interactive Session IV (Interactive Session)

Chair: Yu, Changbin	Australian National Univ.
Co-Chair: Braslavsky, Julio H.	Commonwealth Scientific and Industrial Res. Organisation

14:10-15:10 TuCI1.1

A State-Dependent Switching Law to Quadratically Stabilise Switched Linear Systems, pp. 233-238.

Townsend, Christopher Jacob	Univ. of Newcastle
Seron, Maria M.	Univ. of Newcastle
De Dona, Jose	Univ. of Newcastle

14:10-15:10 TuCI1.2

Reference Design for Predictive Control of Modular Multilevel Converters, pp. 239-244.

Lopez, Andres	Univ. of Newcastle
Quevedo, Daniel E.	Univ. of Newcastle
Aguilera, Ricardo P.	Univ. of Newcastle
Geyer, Tobias	ABB Switzerland
Oikonomou, Nikolaos	ABB Switzerland

14:10-15:10 TuCI1.3

On Multistability of Competitive Neural Networks with Discontinuous Activation Functions, pp. 245-250.

Nie, Xiaobing	Southeast Univ
Zheng, Wei Xing	Univ. of Western Sydney

14:10-15:10 TuCI1.4

Decentralized Sliding Mode Control for Uncertain Discrete-Time Large-Scale Systems: An LMI Approach, pp. 251-256.

Argha, Ahmadreza	Univ. of Tech. Sydney
Li, Li	Univ. of Tech. Sydney
Su, Steven Weidong	Univ. of Tech. Sydney
Nguyen, Hung T.	Univ. of Tech. Sydney

14:10-15:10 TuCI1.5

A Computationally Advantageous Reparameterisation of a Robust Model Predictive Control Scheme, pp. 257-260.

Neshastehriz, Amir Reza	Univ. of Melbourne
Cantoni, Michael	Univ. of Melbourne
Shames, Iman	Univ. of Melbourne

14:10-15:10 TuCI1.6

Challenges with Performance Management of Automatic Control Loops in a Large-Scale Batch Processing Environment, pp. 261-266.

Lees, Michael	Carlton & United Breweries
Ellen, Robert	EGA Tech
Brodie, Paul	Carlton & United Breweries

14:10-15:10 TuCI1.7

Real-Time Obstacle-Avoidance Motion Planning for Autonomous Mobile Robots, pp. 267-272.

Simba, Kenneth Renny	Toyohashi Univ. of Tech
Uchiyama, Naoki	Toyohashi Univ. of Tech
Sano, Shigenori	Toyohashi Univ. of Tech

14:10-15:10	TuCI1.8
Receding Horizon Control for Mass Transport Phenomena in Thermal Fluid Systems, pp. 273-278.	
Satoh, Ryuta	Osaka Univ
Hashimoto, Tomoaki	Osaka Univ
Ohtsuka, Toshiyuki	Kyoto Univ

14:10-15:10	TuCI1.9
Exploring Frequency-Domain Characteristics of Markovian and Non-Markovian Quantum Dynamics, pp. 279-284.	
Xue, Shibei	UNSW Canberra at the Australian Defence Force Acad
Wu, Rebing	Tsinghua Univ
Tarn, Tzyh-Jong	Washington Univ
Petersen, Ian R.	Australian Defence Force Acad

TuDP	STB S1
Estimation (Regular Session)	
Chair: Ford, Jason	Queensland Univ. of Tech.
Co-Chair: Weyer, Erik	Univ. of Melbourne

15:10-15:30	TuDP.1
Design of Observers Implemented Over FlexRay Networks, pp. 285-290.	
Wang, Wei	Univ. of Melbourne
Nesic, Dragan	Univ. of Melbourne
Postoyan, Romain	Centre National De La Recherche Scientifique

15:30-15:50	TuDP.2
A Set Separation Sensor Switching Approach to the Fault Tolerant Control of Linear Parameter Varying Systems, pp. 291-296.	
McCloy, Ryan Josef	Univ. of Newcastle
De Dona, Jose	Univ. of Newcastle
Seron, Maria M.	Univ. of Newcastle

15:50-16:10	TuDP.3
Constrained State Estimation of Nonlinear Dynamical Systems Using Unscented Gaussian Sum Filter, pp. 297-302.	
Kottakki, Krishna Kumar	IIT Bombay
Bhushan, Mani	IIT Bombay
Bhartiya, Sharad	IIT Bombay

Technical Program for Monday November 17, 2014

MoAP	STB S1
Student Best Papers (Regular Session)	
Chair: Cantoni, Michael	Univ. of Melbourne
Co-Chair: Quevedo, Daniel E.	Univ. of Newcastle

08:40-09:00 MoAP.1

Convergence Analysis for Rigid Formation Control with Unrealizable Shapes: The 3 Agent Case, pp. 1-6

Sun, Zhiyong — Australian National Univ
Mou, Shaoshuai — Yale Univ
Helmke, Uwe R. — Univ. of Wuerzburg
Anderson, Brian D.O. — Australian National Univ

We study the outcome of using a gradient descent control law for a minimally rigid formation consisting of N agents, in which each agent is modeled by a single integrator and the desired interagent distances are specified though they are not realizable. We first formulate the problem for formations of N>=3 agents and derive a condition in terms of the rigidity matrix which the final formation must satisfy. Special attention will be given to the triangular formation for which the desired distances fail to satisfy the triangle inequality. In this case, we show the formation converges to a straight line. Detailed analysis is provided to describe the stability properties in the unrealizable triangle shape control problem.

09:00-09:20 MoAP.2

Ultimate Boundedness of Droop Controlled Microgrids with Secondary Loops, pp. 7-12

Heidari, Rahmat — Univ. of Newcastle
Seron, Maria M. — Univ. of Newcastle
Braslavsky, Julio H. — Commonwealth Scientific and Industrial Res. Organisation

In this paper we study theoretical properties of inverter-based microgrids controlled via primary and secondary loops. Stability of these microgrids has been the subject of a number of recent studies. Conventional approaches based on standard hierarchical control rely on time-scale separation between primary and secondary control loops to show local stability of equilibria. In this paper we show that (i) frequency regulation can be ensured without assuming time-scale separation and, (ii) ultimate boundedness of the trajectories starting inside a region of the state space can be guaranteed under a condition on the inverters power injection errors. The trajectory ultimate bound can be computed by simple iterations of a nonlinear mapping and provides a certificate of the overall performance of the controlled microgrid.

09:20-09:40 MoAP.3

Data-Driven Tuning of Nonlinear Internal Model Controllers for Pneumatic Artificial Muscles, pp. 13-18

Takada, Shogo — Kanazawa Univ
Kaneko, Osamu — Kanazawa Univ
Nakamura, Taiki — Kanazawa Univ
Yamamoto, Shigeru — Kanazawa Univ

This paper proposes a data-driven approach to control of the pneumatic artificial muscle (which is abbreviated as PAM). Although the PAM has a desirable advantage of flexible structures, the inherent nonlinear property makes it difficult to obtain a mathematical model and to design an appropriate controller. As one of the ways to overcome such difficulties, a data-driven controller tuning based on the direct use of the data is utilized. Particularly, we apply fictitious reference iterative tuning (which is abbreviated as FRIT), which is a data-driven controller tuning method that enables us to obtain a desirable controller parameter with only one-shot experimental data, for tuning of parameters of controllers to obtain desired response of the PAM. In addition, by introducing internal model controller (which is abbreviated as IMC) that includes a nonlinear mathematical model of the PAM, it is possible to obtain not only the desired controller but also the mathematical model of the PAM. Finally, we also give an experimental result in order to show the validity of the proposed method.

MoBI1	STB S2
Interactive Session I (Interactive Session)	
Chair: Mahony, Robert	Australian National Univ.
Co-Chair: Nurdin, Hendra Ishwara	Univ. of New South Wales

10:05-11:10 MoBI1.1

Max-Plus Fundamental Solution Semigroups for Dual Operator Differential Riccati Equations, pp. 19-24

Dower, Peter M. — Univ. of Melbourne
McEneaney, William — Univ. of California San Diego

Algebraic properties of dynamic programming are exploited to develop a max-plus dual space fundamental solution semigroup of max-plus linear max-plus integral operators for the general solution of a restricted class of operator differential Riccati equations. By examining the kernels of these max-plus linear max-plus integral operators, it is shown that a class of dual operator Riccati equations is defined for which the developed semigroup of operators defines a max-plus primal space fundamental solution semigroup.

10:05-11:10 MoBI1.2

A Popov Approach to Performance Analysis and Coherent Guaranteed Cost Control for Uncertain Quantum Systems, pp. 25-30

Xiang, Chengdi — UNSW Canberra at the Australian Defence Force Acad
Petersen, Ian R. — Australian Defence Force Acad
Dong, Daoyi — Univ. of New South Wales

This paper considers a Popov approach to analyze the performance of an uncertain quantum system, which is subjected to quadratic perturbations in the system Hamiltonian. To get improved performance for this quantum system, a coherent guaranteed cost controller is designed by adding a control Hamiltonian. In this case, a performance comparison between the original uncertain quantum system and the uncertain quantum system with added coherent controller is carried out for an illustrative example.

10:05-11:10 MoBI1.3

UAV Control on the Basis of Bearing-Only Observations, pp. 31-36

Miller, Alexander — Inst. for Information Transmission Problems, RAS
Miller, Boris — Monash Univ

This work considers the control of unmanned aerial vehicles (UAV) on the basis of bearing-only observations including azimuth and elevation angles. During autonomous missions a UAV needs to navigate with the aid of optoelectronic cameras and/or passive radar systems which are able to capture the angular position of objects with known coordinates and to measure the angles of the sight line. Since these measurements involve the real position of the UAV in implicit form, some nonlinear filters such as the Extended Kalman filter (EKF) or others must be used in order to implement these measurements for UAV control. Meanwhile all these approaches to filtering provide the UAV position estimate with unknown and uncontrollable bias, which makes precise navigation rather difficult. At the same time there is the well-known method of pseudomeasurements which reduces the estimation problem to the linear setting, though these methods have a bias also. In this article we suggest the application of V. S. Pugachev filter to the modified pseudomeasurements method without bias. On its basis the estimation and control algorithms for tracking of a given reference path under external perturbation and noisy angular measurements have been developed. Another problem of

tracking for a randomly moving object is also considered and the proposed estimation algorithm shows good results for that problem as well.

10:05-11:10 MoBI1.5

Control of a River Stretch with Uncertain Inflows, pp. 37-42

Nasir, Hasan Arshad Univ. of Melbourne
Weyer, Erik Univ. of Melbourne

Unregulated flows in tributaries to a river carry uncertainties, and due to the long time delays, these flows need to be forecast. For efficient river operations we need a control strategy that can take such forecasts into account and generate a suitable control action. A randomized approach to Stochastic Model Predictive Control for such problems is proposed in this paper. It involves solving a computationally tractable variant of a finite horizon chance-constrained optimization problem. Results from a simulation example show that the strategy performs well.

10:05-11:10 MoBI1.6

Effective Wind Speed Estimation and Optimized Setting Strategy for WTGS Based on SCADA System, pp. 43-48

Hu, Yang North China Electric Power Univ
Liu, Jizhen North China ElectricPower Univ
Chang, Taihua North China Electric Power Univ
Li, Wei North China Electric Power Univ
Lin, Zhongwei Beihang Univ
Meng, Hongmin North China Electric Power Univ

The signal of effective wind speed plays an important role in the process control of Wind Turbine Generation System (WTGS). Due to inaccurate measurement of it, this paper proposes a useful procedure to complete effective wind speed estimation online combining mechanism inference and adaptive data processing algorithm. The historical data in Supervisory Control and Data Acquisition (SCADA) system is used and the Adaptive Neuro-Fuzzy Inference System (ANFIS) is adopted. Moreover, by analyzing the operation of WTGS, a procedure is suggested to establish the aerodynamic charac- teristic related to steady operation points which can be obtained by K-means clustering from SCADA system. Then, according to the effective wind speed, an optimum setting strategy is formulated. The validation is executed and the simulation results show the availability of the approaches.

10:05-11:10 MoBI1.7

Coordinated Control of Once-Through Boiler-Turbine Units Using Feedforward-Feedback Approach Based on Stable Inversion, pp. 49-54

Li, Lu North China Electric Power Univ
Zeng, Deliang North China Electric Power Univ
Chang, Taihua North China Electric Power Univ
Lv, You North China Electric Power Univ

The structural features of the once-through boiler-turbine unit are nonlinear, strong coupling and multi-parameter, which affect the response ability of load of its coordinated control system. In order to improve the control performance of the once-through boiler-turbine coordinated system, a control method of feedforward-feedback control based on the nonlinear model of the once-through boiler-turbine unit was proposed in this article. First a nonlinear model that has certain accuracy and is fit for the controller design was established after reasonable reduce. Then the theory of stable inversion was introduced to seek the inversion solution of the nonlinear model. Feedforward control via inversion system leads the outputs of unit to the set points rapidly, while the feedback controller is designed for multivariable outputs to remove the tracking errors caused by external interference. Finally, simulation tests of the state disturbance and set point perturbation in different static operating conditions were carried out. Simulation results verify that the outputs of feedforward-feedback control method can track the set points accurately and fast.

10:05-11:10 MoBI1.8

Computational Complexity of Robust Schur Stability Analysis by the Generalized Stability Feeler, pp. 55-59

Matsuda, Tadasuke Tokyo Univ. of Science
Matsui, Hajime Toyota Tech. Inst
Kawanishi, Michihiro Toyota Tech. Inst
Narikiyo, Tatsuo Toyota Tech. Inst

The paper gives the computational complexity of the robust Schur stability analysis by the generalized stability feeler. Computational complexity of robust stability analysis is considered as an important characteristic to evaluate robust stability analysis methods. We derive the computational complexity from the algorithm of the generalized stability feeler. The result shows that the robust Schur stability can be checked in polynomial time.

10:05-11:10 MoBI1.9

Short-Data Recursive HMM Parameter Estimation for Rapid Vision-Based Aircraft Heading Estimation, pp. 60-65

Molloy, Timothy Liam Queensland Univ. of Tech
Ford, Jason Queensland Univ. of Tech

Rapid recursive estimation of hidden Markov Model (HMM) parameters is important in applications that place an emphasis on the early availability of reasonable estimates (e.g. for change detection) rather than the provision of longer-term asymptotic properties (such as convergence, convergence rate, and consistency). In the context of vision-based aircraft (image-plane) heading estimation, this paper suggests and evaluates the short-data estimation properties of 3 recursive HMM parameter estimation techniques (a recursive maximum likelihood estimator, an online EM HMM estimator, and a relative entropy based estimator). On both simulated and real data, our studies illustrate the feasibility of rapid recursive heading estimation, but also demonstrate the need for careful step-size design of HMM recursive estimation techniques when these techniques are intended for use in applications where short-data behaviour is paramount.

MoCP STB S1

Control and Estimation of Quantum Systems (Regular Session)

Chair: James, Matthew R. Australian National Univ.
Co-Chair: Dong, Daoyi Univ. of New South Wales

11:10-11:30 MoCP.1

End-To-End Entanglement in a Coherent Feedback Interconnection of Three Nondegenerate Optical Parametric Amplifiers, pp. 66-71

Shi, Zhan Univ. of New South Wales
Nurdin, Hendra Ishwara Univ. of New South Wales

In previous work we have shown that a dual nondegenerate optical parametric amplifier (NOPA) coherent feedback network tolerates transmission losses better and has stronger entanglement (i.e., enhanced two-mode squeezing) than a single NOPA over the same transmission distance. The aim of this paper is to investigate stability, entanglement degree and power consumption of a coherent feedback interconnection of three NOPAs, which connects two spatially separated parties over two transmission channels. The influence of transmission losses in the transmission channels is considered and numerical calculations are given to illustrate advantages for entanglement generation of the triple-NOPA coherent feedback network over a dual-NOPA coherent feedback system.

11:30-11:50 MoCP.2

A Direct Coupling Coherent Quantum Observer for a Single Qubit Finite Level Quantum System, pp. 72-76

Petersen, Ian R. Australian Defence Force Acad

This paper considers the problem of constructing a direct coupling quantum observer for a single qubit finite level quantum system plant. The proposed observer is a single mode linear quantum system which is shown to be able to estimate one of the plant variables in a time averaged sense.

11:50-12:10 MoCP.3

Synchronisation of Micro-Mechanical Oscillators Inside One Cavity Using Feedback Control, pp. 77-82

Miao, Zibo	Australian National Univ
Hosseini, Mahdi	Massachusetts Inst. of Tech
Guccione, Giovanni	Australian National Univ
James, Matthew R.	Australian National Univ

The purpose of this work is to develop a systematic approach towards synchronisation of two micro-mechanical oscillators inside one optical cavity using feedback control. We first obtain the linear quantum stochastic state space model for the optomechanical system considered in this paper. Then we design a measurement-based optimal controller, aimed at achieving complete quantum synchronisation of the two mechanical oscillators with different natural frequencies, in the linear quadratic Gaussian setting. In addition, simulation results are provided, which show how system parameters impact on the control effect. These findings shed light on the synchronised network of oscillators that can be used for memory and quantum state transfer.

12:10-12:30 MoCP.4

Robust Mean Square Stability of Open Quantum Stochastic Systems with Hamiltonian Perturbations in a Weyl Quantization Form, pp. 83-88

Khodaparastsichani, Arash	UNSW Canberra at the Australian Defence Force Acad
Vladimirov, Igor	UNSW Canberra
Petersen, Ian R.	Australian Defence Force Acad

This paper is concerned with open quantum systems whose dynamic variables satisfy canonical commutation relations and are governed by quantum stochastic differential equations. The latter are driven by quantum Wiener processes which represent the external boson fields. The system-field coupling operators are linear functions of the system variables. The Hamiltonian consists of a nominal quadratic function of the system variables and an uncertain perturbation which is represented in a Weyl quantization form. Assuming that the nominal linear quantum system is stable, we develop sufficient conditions for the perturbation of the Hamiltonian which guarantee robust mean square stability of the perturbed system. Examples are given to illustrate these results for a class of Hamiltonian perturbations in the form of trigonometric polynomials of the system variables.

MoDP STB S1

Control Applications (Regular Session)

Chair: Manchester, Ian R.	Univ. of Sydney
Co-Chair: Dower, Peter M.	Univ. of Melbourne

14:00-14:20 MoDP.1

Vulnerability Analysis of Large-Scale Dynamical Networks to Coordinated Attacks, pp. 89-94

Nandanoori, Sai Pushpak	Iowa State Univ
Diwadkar, Amit	Iowa State Univ
Vaidya, Umesh	Iowa State Univ
Fardad, Makan	Syracuse Univ

We study the vulnerability of large-scale linear dynamical networks to coordinated attacks. We consider scenarios in which an attacker can tamper with the links connecting the network components and can also manipulate input injections at the nodes. When these two types of attacks take place simultaneously, the attack is referred to as a coordinated attack. We assume that network links are attacked with a certain probability and that malicious data is injected at the input ports. We employ Markov jump linear systems to model link-based attacks and the system input matrix to model data injection attacks. System theoretic vulnerability metrics developed in earlier work are used to analyze network vulnerability to coordinated attacks. These measures of vulnerability allow us to characterize the impact of coordinated attacks and the difficulty associated with detecting them. Finally, we analyze the vulnerability of coordinated attacks on the New England 39 bus power network.

14:20-14:40 MoDP.2

Hot-Start Efficiency of Quadratic Programming Algorithms for Fast Model Predictive Control: A Comparison Via an Adaptive Optics Case Study, pp. 95-100

Konnik, Mikhail	Univ. of Newcastle
De Dona, Jose	Univ. of Newcastle

Model Predictive Control (MPC) with fast sampling rates can be extremely demanding in terms of the required computational time. However, the control problem in some cases does not change much from one sampling instance to the next, and therefore hot-start can be used to considerably accelerate the solution of an online optimisation problem. An adaptive optics system is used in this work as an example of such a control system to evaluate the benefits of hot-start for different families of optimisation algorithms. A comparison of the computational times and a discussion of hot-start efficiency for Interior Point, Active Set, Gradient-based and Augmented Lagrangian algorithms are provided in this contribution.

14:40-15:00 MoDP.3

Geoengineering Via Solar Radiation Management As a Feedback Control Problem: Controller Design for Disturbance Rejection, pp. 101-106

Weller, Steven	Univ. of Newcastle
Schulz, Brenton	Univ. of Newcastle

Recent research has proposed the use of feedback of the observed climate to adjust the radiative forcing of solar radiation management (SRM)-based geoengineering schemes, which involve deliberate and large-scale intervention in the planetary environment to counteract anthropogenic climate change. Feedback in an SRM scheme has the potential to compensate for uncertainty in both the forcing and the climate response, and for unexpected changes in the climate system. The long-term warming effects arising from anthropogenic emission of greenhouse gases are thereby (at least partially) offset,in such a way that neither natural climate variability nor measurement noise is unduly amplified. In this paper SRM is framed as a feedback control problem for disturbance rejection, drawing on H-infinity-synthesis as a formal framework in which the effect of anthropogenic climate disturbances can be minimized. The effectiveness of both an H-infinity-suboptimal SRM controller and a simple proportional-integral (PI) controller is demonstrated on the reduced-complexity climate model MAGICC. The extent and speed with which negative radiative forcing could feasibly be implemented and sustained impose tight constraints on the effectiveness of the control actuation authority in an SRM climate control loop. This in turn suggests caution in relying heavily on feedback to counterbalance uncertainty in the climate system when implementing SRM.

15:00-15:20 MoDP.4

Time Weighted Model Reduction of Flat Plate Solar Collectors, pp. 107-111

Jazlan, Ahmad	Univ. of Western Australia
Sreeram, Victor	Univ. of Western Australia
Togneri, Roberto	Univ. of Western Australia
Bettayeb, Maamar	Univ. of Sharjah

This paper presents the application of time weighted model reduction using cross gramians on a state space model derived from two partial differential equations representing the instantaneous thermal balance of a differential element of length along the absorber plate and the absorber plate to fluid heat convection process respectively of a flat plate solar collector. Finite difference method is applied onto both these partial differential equations where discretization in time and space is performed resulting in a high order linear discrete time invariant Single Input Single Output (SISO) state space model. Numerical results are provided to demonstrate and compare the performance of time weighted model reduction relative to balanced truncation.

MoEI1 STB S2

Interactive Session II (Interactive Session)

Chair: Trumpf, Jochen — Australian National Univ.

Co-Chair: De Dona, Jose — Univ. of Newcastle

15:45-17:00 MoEI1.1

A New Non-Iterative Solution for a Class of Difference Riccati Equations, pp. 112-117

Zhang, Huan — Univ. of Melbourne

Dower, Peter M. — Univ. of Melbourne

Recently, two non-iterative solutions for difference Riccati equations (DREs) have been developed employing max-plus primal and dual space fundamental solution semigroups. These solutions provide explicit formulas that allow the non-iterative computation of the DRE solution corresponding to any initial condition in a specific well-defined set. In this paper, a third non-iterative solution to a class of difference Riccati equation is developed. It is shown that this new non-iterative solution avoids some specific drawbacks observed in the two existing max-plus based non-iterative solutions at the expense of a semigroup property.

15:45-17:00 MoEI1.2

A Quantum Mechanical Version of Price's Theorem for Gaussian States, pp. 118-123

Vladimirov, Igor — UNSW Canberra

This paper is concerned with integro-differential identities which are known in statistical signal processing as Price's theorem for expectations of nonlinear functions of jointly Gaussian random variables. We revisit these relations for classical variables by using the Frechet differentiation with respect to covariance matrices, and then show that Price's theorem carries over to a quantum mechanical setting. The quantum counterpart of the theorem is established for Gaussian quantum states in the framework of the Weyl functional calculus for quantum variables satisfying the Heisenberg canonical commutation relations. The quantum mechanical version of Price's theorem relates the Frechet derivative of the generalized moment of such variables with respect to the real part of their quantum covariance matrix with other moments. As an illustrative example, we consider these relations for quadratic-exponential moments which are relevant to risk-sensitive quantum control.

15:45-17:00 MoEI1.3

Approximate Bang-Bang Lyapunov Control for Closed Quantum Systems, pp. 124-129

Kuang, Sen — Univ. of Science and Tech. of China

Dong, Daoyi — Univ. of New South Wales

Petersen, Ian R. — Australian Defence Force Acad

This paper proposes a new approximate bang-bang Lyapunov control that can achieve rapid state control for quantum systems. A construction method is presented to design the degrees of freedom in the Lyapunov function so that the control law can guarantee the convergence of the system to a target eigenstate being isolated in the invariant set. Simulation experiments on a three-level system demonstrate that the proposed method can achieve good performance for rapid state control of quantum systems.

15:45-17:00 MoEI1.4

Negative Imaginary Feedback Systems, pp. 130-133

Mabrok, Mohamed — UNSW Canberra at the Australian Defence Force Acad

Petersen, Ian R. — Australian Defence Force Acad

The stability results for interconnected negative imaginary systems are key results in negative imaginary systems theory. In this paper, we consider a generalized version of negative imaginary feedback systems based on a generalized negative imaginary system definition and a generalized negative imaginary lemma. The generalized negative imaginary system definition allows for free body motion. This extensions allows for an important class of systems to be included in the negative imaginary framework.

15:45-17:00 MoEI1.5

Finite-Horizon H-Infinity Control for a Class of Time-Varying Nonlinear Systems Subject to Sensor and Actuator Saturations, pp. 134-139

Wei, Yunliang — Nanjing Univ. of Science and Tech

Zheng, Wei Xing — Univ. of Western Sydney

In this paper, a time-varying dynamic output feedback controller is designed, which aims to solve the finite-horizon H-infinity control problem for a class of discrete-time time-varying nonlinear systems subject to actuator and sensor saturations. The nonlinearities of the system under consideration satisfy the sector conditions, which include the Lipschitz nonlinearities as a special case. To effectively handle the saturation nonlinearities, a compact convex hull representation is utilized, which leads to less conservative conditions for the controller design than the existing results due to imposition of extra slack variables. The sufficient conditions derived are expressed in the form of a series of recursive linear matrix inequalities. By outlining an implementation algorithm, the finite-horizon H-infinity controller can be designed online. Finally, a numerical example is presented to demonstrate the feasibility and efficacy of the proposed method.

15:45-17:00 MoEI1.6

Inversion Formulae for the Design of PIDF Controllers, pp. 140-145

Cuoghi, Stefania — Univ. of Modena and Reggio Emilia

Ntogramatzidis, Lorenzo — Curtin Univ

This paper introduces a set of closed-form formulae for the design of PIDF (i.e., PID + filter) controllers to exactly satisfy steady state requirements and standard frequency-domain specifications on the stability margins (i.e., phase and gain margins) and the gain crossover frequency. This design methodology is an extension of the so called Inversion Formulae method for the design of classical Lead, Lag, Notch and PI/PD/PID controllers. PIDF controllers are useful because, differently from standard PID controllers, they are described by a proper transfer function. In this paper we also show that the further degree of freedom introduced in the transfer function of the PIDF controller can be exploited to satisfy further specifications, compared to the classic PID controller.

15:45-17:00 MoEI1.7

Distributed Consensus of Linear Multi-Agent Systems with Switching Directed Topologies, pp. 146-151

Wen, Guanghui — Southeast Univ

Ugrinovskii, Valery — Univ. of New South Wales

This paper addresses the distributed consensus problem for a linear multi-agent system with switching directed communication topologies. By appropriately introducing a linear transformation, the consensus problem is equivalently converted to the stabilization problem of a class of switched linear systems. Some sufficient consensus conditions are then derived by using tools from matrix theory and stability analysis of switched systems. It is proved that consensus in such a multi-agent system can be ensured if each agent is stabilizable and each possible directed topology contains a directed spanning tree. Finally, a numerical simulation is given for illustration.

15:45-17:00 MoEI1.9

Passivity-Based Adaptive Control for Visually Servoed Robotic Systems, pp. 152-157

Wang, Hanlei — Beijing Inst. of Control Engineering

This paper investigates the visual servoing problem for robotic systems with uncertain kinematic, dynamic, and camera parameters. We first present the passivity properties associated with the overall kinematics of the system, and then propose a

passivity-based adaptive control scheme to resolve the visual tracking problem. With the Lyapunov analysis approach, it is shown that the image-space tracking errors converge to zero irrespective of the invertibility of the estimated depth. A simulation is performed to show the tracking performance of the proposed adaptive controller.

MoPP STB S1

Plenary Lecture 1 (Plenary Session)

Chair: Ugrinovskii, Valery Univ. of New South Wales

17:00-18:00 MoPP.1

*High-Speed Atomic Force Microscopy: Mechatronic Design and Control Challenges**

Moheimani, S.O. Reza Univ. of Newcastle

The Atomic Force Microscope (AFM) is one of the most remarkable scientific instruments to emerge out of the 20th century. Imaging in 3D with atomic resolution is one of the most unique features of the AFM. Unlike traditional light and scanning electron microscopes (SEMs) which create images of matter by measuring the intensity of reflected electromagnetic radiation, the sharp tip of an AFM micro-probe reacts to the sample surface and thus the AFM creates images by mechanically "feeling" the surface with the micro-probe. While the resolution of light microscopy is limited by the refraction of visible light, and SEMs on the diffraction of electron beams, the resolution of the AFM is directly related to the precision and accuracy of positioning the AFM probe relative to a sample surface. Additionally, the throughput of the AFM is limited by how fast the probe can be positioned over the specimen. Increasing the throughput of an AFM while maintaining its high accuracy amounts to a significant challenge. This talk reports on recent efforts to develop video-rate atomic force microscopes for direct observation of dynamic processes at extremely high resolutions by combining innovative mechatronic design and high-performance control.

Technical Program for Tuesday November 18, 2014

TuPP STB S1

Plenary Lecture 2 (Plenary Session)

Chair: Mahony, Robert Australian National Univ.

08:30-09:30 TuPP.1

*A Theory of Information for Nonstochastic Estimation and Control**

Nair, Girish N. Univ. of Melbourne

Shannon's probabilistic concept of information is a central tool for delineating fundamental performance limits in communication systems. With the advent of networked control systems, information has also gained renewed appreciation as a concept in control theory, and it is now understood that stochastic control performance is related to the amount of information flowing in the feedback loop. However, unlike in communications, disturbances in control are often modelled as deterministic unknowns with bounded magnitude or power. In such systems, Shannon's original probabilistic framework is inapplicable. This raises the question of whether it is possible to construct useful analogues of independence, Markovness and information for estimation and control, without having to assume a statistical model. This talk describes a recent framework for doing so, leading to the construction of nonstochastic versions of information and directed information. It is shown that the largest nonstochastic information rate through an error-prone channel coincides exactly with its operational zero-error capacity and, similarly, that the largest nonstochastic directed information yields the operational zero-error feedback capacity. These results lead to tight conditions for estimating or controlling the state of a linear system over an erroneous communication channel, under the requirement of bounded estimation errors or states. The extension to multi-agent systems is then discussed.

TuAI1 STB S2

Interactive Session III (Interactive Session)

Chair: Kellett, Chris Univ. of Newcastle

Co-Chair: Zheng, Wei Xing Univ. of Western Sydney

09:55-11:00 TuAI1.1

Model Validation and Set Membership State Estimation for Continuous-Time Nonlinear Systems: Contraction Metric Approach, pp. 158-163

Ouyang, Hua Univ. of New South Wales

Manchester, Ian R. Univ. of Sydney

This paper studies the set membership state estimation(SMSE) and model validation for continuous-time nonlinear systems with uncertainties. These two problems are formulated as nonlinear optimal tracking problems with reversed time while such optimal problems cannot be solved analytically for nonlinear systems, as for linear systems. This paper proposes a novel approach based on contraction theory to obtain an upper bound of the cost functional of nonlinear tracking problem. Minimizing the upper bound leads to an approximate solution to the nonlinear tracking problem. This approach is applied to the SMSE and model validation problems and it leads to a sufficient condition for the existence of solutions to these two problems. Through minimizing the upper bound, approximate state estimation membership set is obtained. Also, the outline of how to use Sum-of-Square (SOS) programming to compute the solutions is discussed.

09:55-11:00 TuAI1.2

An Investigation of Set-Theoretic Methods for Fault Detection in Lure Systems, pp. 164-169

Hanafi, Ainain Nur Univ. of Newcastle

Seron, Maria M. Univ. of Newcastle

De Dona, Jose Univ. of Newcastle

A recently proposed set-theoretic approach to fault diagnosis is based on membership of residual signals to (invariant) sets that characterise healthy and faulty system behaviour. Correct diagnosis is achieved if the relevant sets are disjoint. Tighter sets that allow separation for a larger class of faults are hence desirable within this approach. In this paper, we investigate methods to compute invariant sets for a Lure system from two different perspectives: by bounding the nonlinear terms and by embedding the nonlinear system in a linear parameter varying (LPV) model. To analyse and compare the methods, we develop a scalar and a second-order system case, and provide an example of a latter system. The results show that both approaches can be used for fault diagnosis and yield comparable performance for this type of systems under specific conditions.

09:55-11:00 TuAI1.3

On a New Uniform Dynamic Coding Algorithm for Model-Based Networked Control Systems, pp. 170-175

Wang, Gexia Shanghai Univ. of Electric Power

Tan, Ying Univ. of Melbourne

Mareels, Iven Univ. of Melbourne

This paper focuses on a special form of networked control systems (NCSs): model-based NCSs (MB-NCSs). MB-NCSs were proposed in order to reduce the number of data packet exchanges between sensors and controllers/actuators by using linear-time-invariant nominal models and some appropriate coder and decoder algorithms. This paper proposes a new uniform dynamic coding and decoding algorithm for MB-NCSs whose design parameters depend on the choice of the controller for the nominal model, the model mismatch between the nominal model and the plant as well as the sampling period. This new algorithm can ensure that the closed loop stability of MB-NCSs by choosing proper coding and decoding parameters. The robustness of this algorithms with respect to the model mismatch has also been addressed. Simulation results demonstrate the effectiveness of the proposed algorithm.

09:55-11:00 TuAI1.4

Pruning Error Analysis for a Class of Curse-Of-Dimensionality Free Methods, pp. 176-181

Zhang, Huan — Univ. of Melbourne
Dower, Peter M. — Univ. of Melbourne

In the context of computational nonlinear optimal control, curse-of-dimensionality (CoD) refers to the phenomenon of exponential growth of computational cost with respect to the dimension of state and input space. It is well-known that CoD is the major drawback of grid-based computational methods, which are consequently restricted their applications to low dimensional problems. Switching linear quadratic regulators (SLQR) is a class of nonlinear optimal control problems for which a CoD free method has been developed. However, it has been observed that this CoD free method suffers from a different form of computational complexity known as curse-of-complexity (CoC) which refers to the phenomenon that the number of quadratics necessary to represent the value functions of SLQR problems increases exponentially with respect to time horizon. Pruning is the key method of tackling this class of complexity at the cost of introducing pruning errors. This paper develops a framework that can be used to analyse pruning errors.

09:55-11:00 TuAI1.5

Model Predictive Control of Differentially Flat Systems Using Haar Wavelets, pp. 182-187

Wang, Ruigang — Univ. of New South Wales
Tippett, Michael James — Univ. of New South Wales
Bao, Jie — Univ. of New South Wales

A dynamical system is differentially flat if it is Lie-Backlund (L-B) equivalent to a free dynamical system which has dimension equal to that of the input of the original system. By the virtue of differential flatness, the classical nonlinear model predictive control optimization problem can be reduced to a lower dimensional nonlinear programming problem with respect to the flat outputs. A novel computational method based on Haar wavelets in the time-domain for solving the resulting nonlinear programming problem is developed to obtain an approximation of the optimal flat output trajectory. The Haar wavelet integral operational matrix is utilized to transform the nonlinear programming problem to a finite dimensional nonlinear static optimization problem. Thus, the proposed approach utilizes flatness as a structural property of nonlinear systems, and the convenient mathematical properties of Haar wavelets to develop an efficient computational algorithm for nonlinear model predictive control of differentially flat systems.

09:55-11:00 TuAI1.6

Detectability of Distributed Consensus-Based Observer Networks: An Elementary Analysis and Extensions, pp. 188-192

Ugrinovskii, Valery — Univ. of New South Wales

This paper continues the study of local detectability and observability requirements on components of distributed observers networks to ensure detectability properties of the network. First, we present a sketch of an elementary proof of the known result equating the multiplicity of the zero eigenvalue of the Laplace matrix of a digraph to the number of its maximal reachable subgraphs. Unlike the existing algebraic proof, we use a direct analysis of the graph topology. This result is then used in the second part of the paper to extend our previous results which connect the detectability of an observer network with corresponding local detectability and observability properties of its node observers. The proposed extension allows for nonidentical matrices to be used in the interconnections.

09:55-11:00 TuAI1.7

Further Results on a Class of Nonlinear Protocols in Networked Systems, pp. 193-198

Emadi, Hamid — Iowa State Univ
Srivastava, Vaibhav — Princeton Univ
Vaidya, Umesh — Iowa State Univ
Bhattacharya, Sourabh — Iowa State Univ

In this paper, we investigate the behaviour of networked systems under two different nonlinear protocols: 1) Pitchfork bifurcation nonlinearity in absolute flow 2) Hopf bifurcation nonlinearity in disagreement flow. The former one is the extension of the results proposed in a recent paper by Srivastava, Moehlis and Bullo for the case when individual agents are free to choose a parameter that defines their own dynamics. Based on the eigenvalues of the linearized system, we characterize the set of equilibria that could be achieved under the above protocols. Furthermore, we provide sufficient conditions to achieve consensus for both protocols. Finally, we show that changing the parameter values leads to bifurcation for the entire network. For each protocol, we analyze system with two and three agents, and present a characterization of the steady-state behaviour of the entire system.

09:55-11:00 TuAI1.8

Gain Scheduling Control for Magnetic Levitation Device Using Redundant Descriptor Representation, pp. 199-204

Kumada, Tatsuro — Nanzan Univ
Chen, Gan — Nanzan Univ
Takami, Isao — Nanzan Univ

This paper proposes Gain Scheduling (GS) control for magnetic levitation device using redundant descriptor representation. The purpose of this study is to stably float a steel ball and let the distance between a coil and a steel ball follow the reference without error. GS control has a potential not only to deal with large variation range but also to improve the control performance. In this study, designed controllers are able to let a steel ball float stably in not a one equilibrium point but some variation range by scheduling an equilibrium point. However, designing a GS controller is difficult in the framework of state space representation. The redundancy of descriptor representation is applied to this difficulty. It is shown that a GS controller can be easily designed by introducing redundant descriptor variables. The robust stability for the system with uncertain parameters is guaranteed theoretically by using matrix polytope representation. Then, the problem is formulated as solving a finite set of Linear Matrix Inequalities (LMI) based on previous research. Finally, the effectiveness of the proposed method is verified by comparing a GS controller and a robust LQ controller in some simulations and experiments.

09:55-11:00 TuAI1.9

Robustness of the Characteristic Model-Based Golden-Section Adaptive Control, pp. 205-210

Huang, Huang — Beijing Inst. of Control Engineering

The characteristic model-based golden-section adaptive control law (CM-GSAC) has been developed for over 20 years in China with a broad range of applications in various fields. This paper discusses the optimization of the first two control coefficients such that the closed-loop system can tolerate the largest parameter estimation error. The Vinnicombe distance is introduced as a metric to evaluate the distance between the true CM and the estimated CM. According to the simulation results, system with CM-GSAC shows better tracking performance than that of the well known model-reference adaptive control and the multiple model adaptive control.

TuBP STB S1

Nonlinear/Robust/Model Predictive Control (Regular Session)

Chair: Nesic, Dragan — Univ. of Melbourne
Co-Chair: Ntogramatzidis, Lorenzo — Curtin Univ.

11:00-11:20 TuBP.1

Frequency-Domain Stability Criteria for Distributed-Parameter Systems under Periodic Sampled-Data Feedback Control, pp. 211-214

Kao, Chung-Yao — National Sun Yat-Sen Univ
Cantoni, Michael — Univ. of Melbourne

The stability of distributed-parameter systems operating under

periodic sampled-data feedback control is studied via integral-quadratic constraints (IQCs). Simple sufficient frequency-domain stability criteria are derived for the feedback interconnection of a plant with (irrational) Callier-Desoer class transfer function and a feedback controller obtained via the periodic sample-and-hold discretization of an LTI controller with rational transfer function. The analysis is underpinned by a time-varying delay model of the sample-and-hold operation and IQC characterizations of a related system.

11:20-11:40 TuBP.2

Output-Feedback Control of Nonlinear Systems Using Control Contraction Metrics and Convex Optimization, pp. 215-220

Manchester, Ian R. Univ. of Sydney

Slotine, Jean-Jacques E. Massachusetts Inst. of Tech

Control contraction metrics (CCMs) are a new approach to nonlinear control design based on contraction theory. The resulting design problems are expressed as pointwise linear matrix inequalities and are and well-suited to solution via convex optimization. In this paper, we extend the theory on CCMs by showing that a pair of "dual" observer and controller problems can be solved using pointwise linear matrix inequalities, and that when a solution exists a separation principle holds. That is, a stabilizing output-feedback controller can be found. The procedure is demonstrated using a benchmark problem of nonlinear control: the Moore-Greitzer jet engine compressor model.

11:40-12:00 TuBP.3

Offset-Free Output Feedback Predictive Control for Longitudinal Beam Dynamics in Heavy Ion Synchrotrons, pp. 221-226

Faulwasser, Timm Ec. Pol. Fédérale De Lausanne

Lens, Dieter TU Darmstadt

Kellett, Chris Univ. of Newcastle

Control of the longitudinal beam dynamics in heavy ion synchrotrons is a challenging task due primarily to the very fast time constants present in the system. Recently, the authors developed a model predictive controller for this system and demonstrated that solution of the required optimisation problem can be accomplished in about 1 microsecond when implemented on a Field Programmable Gate Array (FPGA). This initial design made several simplifying assumptions and in this paper we extend this initial design to account for known implementation issues relevant to the SIS18 heavy ion synchrotron at the GSI Helmholtz Center. In particular, in this paper we present a design of an offset-free output feedback predictive control scheme for longitudinal beam dynamics in heavy ion synchrotrons. Furthermore, we demonstrate how to compensate for possible communication delays. The performance of this offset-free output feedback predictive controller is validated in simulation.

12:00-12:20 TuBP.4

Nonlinear L2-Gain Verification for Bilinear Systems, pp. 227-232

Dower, Peter M. Univ. of Melbourne

Kellett, Chris Univ. of Newcastle

A general class of bilinear systems is shown to satisfy a nonlinear L2-gain property that naturally generalizes the standard (linear) L2-gain inequality. This property is demonstrated via direct construction of appropriate transient and gain bounds, and by the application of existing dissipation-based verification results that involve the solution of a Hamilton-Jacobi-Bellman partial differential equation. An example illustrating the obtained bounds is also included, along with a discussion concerning interconnections of such systems.

TuCI1 STB S2

Interactive Session IV (Interactive Session)

Chair: Yu, Changbin Australian National Univ.

Co-Chair: Braslavsky, Julio H. Commonwealth Scientific and Industrial Res. Organisation

14:10-15:10 TuCI1.1

A State-Dependent Switching Law to Quadratically Stabilise Switched Linear Systems, pp. 233-238

Townsend, Christopher Jacob Univ. of Newcastle

Seron, Maria M. Univ. of Newcastle

De Dona, Jose Univ. of Newcastle

This paper generalises a Lyapunov based control strategy, developed in a paper by Wicks, Peleties and DeCarlo, which stabilises a switched linear system consisting of a pair of sub-systems, to a system consisting of arbitrarily many sub-systems. It is shown that the existence of a stable convex combination of the system matrices is a sufficient condition for the proposed control law to stabilise the switched system. Three examples are given of the proposed control law stabilising a system.

14:10-15:10 TuCI1.2

Reference Design for Predictive Control of Modular Multilevel Converters, pp. 239-244

Lopez, Andres Univ. of Newcastle

Quevedo, Daniel E. Univ. of Newcastle

Aguilera, Ricardo P. Univ. of Newcastle

Geyer, Tobias ABB Switzerland

Oikonomou, Nikolaos ABB Switzerland

This paper proposes a reference design technique for the control of Modular Multilevel Converters. Assuming balanced operation, a reduced-order model for the power converter is developed and its state trajectories are characterized in closed form. This allows one to specify desired references for the current and voltage at the load, and also for the circulating current and capacitor voltages in the converter. A simulation study using finite-set constrained predictive control illustrates advantages of the proposed method.

14:10-15:10 TuCI1.3

On Multistability of Competitive Neural Networks with Discontinuous Activation Functions, pp. 245-250

Nie, Xiaobing Southeast Univ

Zheng, Wei Xing Univ. of Western Sydney

In this paper, we examine the problem of multistability for competitive neural networks associated with discontinuous non-monotonic piecewise linear activation functions. First, we derive certain sufficient conditions for coexistent multiple equilibrium points, which reveals that the n-neuron competitive neural networks under study can possess as many as 4 to the power of n equilibrium points. Next, we investigate local stability of those multiple equilibrium points, which shows that 3 to the power of n equilibrium points are locally stable. The new multistability results are obtained by virtue of the fixed point theorem and the theory of strict diagonal dominance matrix. The theoretical results are finally validated by a numerical example along with computer simulations.

14:10-15:10 TuCI1.4

Decentralized Sliding Mode Control for Uncertain Discrete-Time Large-Scale Systems: An LMI Approach, pp. 251-256

Argha, Ahmadreza Univ. of Tech. Sydney

Li, Li Univ. of Tech. Sydney

Su, Steven Weidong Univ. of Tech. Sydney

Nguyen, Hung T. Univ. of Tech. Sydney

In this paper, a decentralized discrete-time sliding mode control is designed for the uncertain large-scale systems. Firstly, a decentralized sliding surface is developed for the largescale discrete-time systems including uncertainty and exogenous disturbance. Then, a decentralized sliding mode controller is designed for the underlying systems. An LMI approach is deployed to develop a new framework to design the decentralized sliding mode controller which can stabilize the underlying uncertain large-scale system. The ultimate boundedness of the state and sliding function of the underlying closed-loop system is studied accordingly. Illustrative examples are presented to show the effectiveness of the proposed controllers.

14:10-15:10 TuCI1.5

A Computationally Advantageous Reparameterisation of a Robust Model Predictive Control Scheme, pp. 257-260

Neshastehriz, Amir Reza — Univ. of Melbourne
Cantoni, Michael — Univ. of Melbourne
Shames, Iman — Univ. of Melbourne

In this paper, a two step reparameterisation is proposed to reduce the computational cost of an online constraint tightening model predictive control (MPC) scheme for control of linear systems subject to time-varying state constraints and a bounded disturbance. The method is an exact reparameterisation based on well-established linear algebra techniques and does not cause degradation in the performance when compared to the original problem. Applying the reparameterisation, a smaller problem is to be solved at each step which yields computational benefits as demonstrated via a numerical example.

14:10-15:10 TuCI1.6

Challenges with Performance Management of Automatic Control Loops in a Large-Scale Batch Processing Environment, pp. 261-266

Lees, Michael — Carlton & United Breweries
Ellen, Robert — EGA Tech
Brodie, Paul — Carlton & United Breweries

Process-related industries (many of which are inherently batch-related) account for a significant portion of the manufacturing sector. Many advances have been made in the field of process control, some of which are related to performance management of control loops. However, much of this work assumes continuous operation of the control loops. Many of the challenges presented by batch environments relate to a requirement to cater for both interruptions to control loops as well as varying plant dynamics. This paper provides both an overview of the general issues that are likely to be encountered in a batch environment as well as some deeper insights into a number of specific challenges. Some examples are provided based on experience within one of Australia's largest breweries. Despite this being a topic of emerging importance to manufacturing industries there is very little objective (non-commercial) information on these challenges available in the literature. This material will be of benefit to researchers who have an interest in realistic industrial control applications. It is also intended to be of use for those in industry by providing a realistic set of issues and challenges that are specific to batch environments.

14:10-15:10 TuCI1.7

Real-Time Obstacle-Avoidance Motion Planning for Autonomous Mobile Robots, pp. 267-272

Simba, Kenneth Renny — Toyohashi Univ. of Tech
Uchiyama, Naoki — Toyohashi Univ. of Tech
Sano, Shigenori — Toyohashi Univ. of Tech

This article focuses on generation of a smooth obstacle avoidance trajectory for wheeled mobile robots in real-time. The algorithm is based on visibility graph and Bezier curves with properties ideally suited for this purpose. To increase the efficient of our algorithm, we introduced a simple but effective method for constructing visibility graphs by ignoring unnecessary nodes. Our developed algorithm generates smooth and distance-optimal motion trajectories. The algorithm is computationally efficient and easy to implement making it suitable for real-time as well as off-line path planning applications. Simulation results demonstrate the feasibility of the proposed method.

14:10-15:10 TuCI1.8

Receding Horizon Control for Mass Transport Phenomena in Thermal Fluid Systems, pp. 273-278

Satoh, Ryuta — Osaka Univ
Hashimoto, Tomoaki — Osaka Univ
Ohtsuka, Toshiyuki — Kyoto Univ

This paper examines the control problem of mass transport phenomena in thermal fluid systems. The system model considered here is described by the momentum, continuity, energy and mass transport equations. Receding horizon control is one of the most successful control methodologies because of its applicability to a wide range of applications.The objective in this study is to propose a design method of receding horizon controller for mass transport phenomena in thermal fluid systems. The effectiveness of the proposed method is verified by numerical simulations.

14:10-15:10 TuCI1.9

Exploring Frequency-Domain Characteristics of Markovian and Non-Markovian Quantum Dynamics, pp. 279-284

Xue, Shibei — UNSW Canberra at the Australian Defence Force Acad
Wu, Rebing — Tsinghua Univ
Tarn, Tzyh-Jong — Washington Univ
Petersen, Ian R. — Australian Defence Force Acad

This paper presents a Green's function based root locus method to investigate the frequency-domain characteristics of Markovian and non-Markovian open quantum systems. A Langevin equation for the system is derived, where we show the structure of the Green's function dominates the system dynamics. In addition, by increasing the coupling between the system and its environment, variations in the modes of the Green's function are explored in the frequency domain, where both the critical transition from Markovian to non-Markovian dynamics and a critical point condition under Lorentzian noise are graphically presented using a root locus method. Related results are verified using an example of a boson-boson coupling system.

TuDP STB S1

Estimation (Regular Session)

Chair: Ford, Jason — Queensland Univ. of Tech.
Co-Chair: Weyer, Erik — Univ. of Melbourne

15:10-15:30 TuDP.1

Design of Observers Implemented Over FlexRay Networks, pp. 285-290

Wang, Wei — Univ. of Melbourne
Nesic, Dragan — Univ. of Melbourne
Postoyan, Romain — Centre National De La Recherche Scientifique

We investigate the observer design for nonlinear systems whose measurements are sent over a network governed by FlexRay. FlexRay is a communication protocol used in the automotive industry which has the feature to switch between two scheduling rules associated with the two segments of its communication cycles. The objective of this paper is to generalize existing works on emulated observers for networked control systems (NCS) to be applicable to NCS with FlexRay. We propose for that purpose a novel hybrid model and guarantee the observer convergence provided that, for each segment, the scheduling rules are uniformly globally exponentially stable and the maximal allowable transmission interval satisfy given explicit bounds. The analysis relies on the use of an hybrid Lyapunov function we recently constructed to investigate the stabilization of NCS with FlexRay. We finally apply the approach to a class of globally Lipschitz systems, which includes linear time-invariant systems as a particular case.

15:30-15:50 TuDP.2

A Set Separation Sensor Switching Approach to the Fault Tolerant Control of Linear Parameter Varying Systems, pp. 291-296

McCloy, Ryan Josef — Univ. of Newcastle
De Dona, Jose — Univ. of Newcastle
Seron, Maria M. — Univ. of Newcastle

We propose a fault tolerant control (FTC) scheme that compensates for sensor faults in linear parameter varying systems via multiple sensor switching. The scheme consists of a

closed-loop system with an estimator-based feedback tracking controller that switches between sensor-estimate pairings based on a sufficient set separation criterion, which considers both model uncertainty and system disturbances. Under the proposed scheme, preservation of closed-loop system boundedness is guaranteed for a wide range of sensor fault situations. An example is presented to illustrate the performance of the FTC strategy.

15:50-16:10 TuDP.3

Constrained State Estimation of Nonlinear Dynamical Systems Using Unscented Gaussian Sum Filter, pp. 297-302

Kottakki, Krishna Kumar IIT Bombay

Bhushan, Mani IIT Bombay

Bhartiya, Sharad IIT Bombay

Unscented Kalman Filter (UKF) approaches are popular due to the absence of linearization steps as well as their use of a deterministically chosen but limited set of samples (labeled sigma points). However, UKF is based on an implicit assumption that the conditional state densities at various steps are Gaussian. The assumption of Gaussianity is then carried over to the various extensions of UKF available in literature for incorporating constraints on states. This, in turn, leads to potentially inferior performance of the constrained state estimators if the densities are significantly non-Gaussian. To overcome this issue, various attempts have been made that represent the conditional densities as a Gaussian Sum. The use of large number of Gaussians renders these methods computationally demanding. Recently, an Unscented Gaussian Sum Filter (UGSF) has been proposed that uses a Sum of Gaussian approximation using only the sigma points as generated in UKF. It was shown by the authors that UGSF outperforms the UKF while using a similar computational effort as the UKF. In this work, we propose to modify the UGSF to incorporate constraints on the states in the estimation process. We propose to use Interval Constrained Unscented Transformation (ICUT) and probability density function truncation algorithms with the UGSF framework. Implementation on the three state isothermal batch reactor case study shows that the proposed constrained UGSF outperforms constrained UKF.

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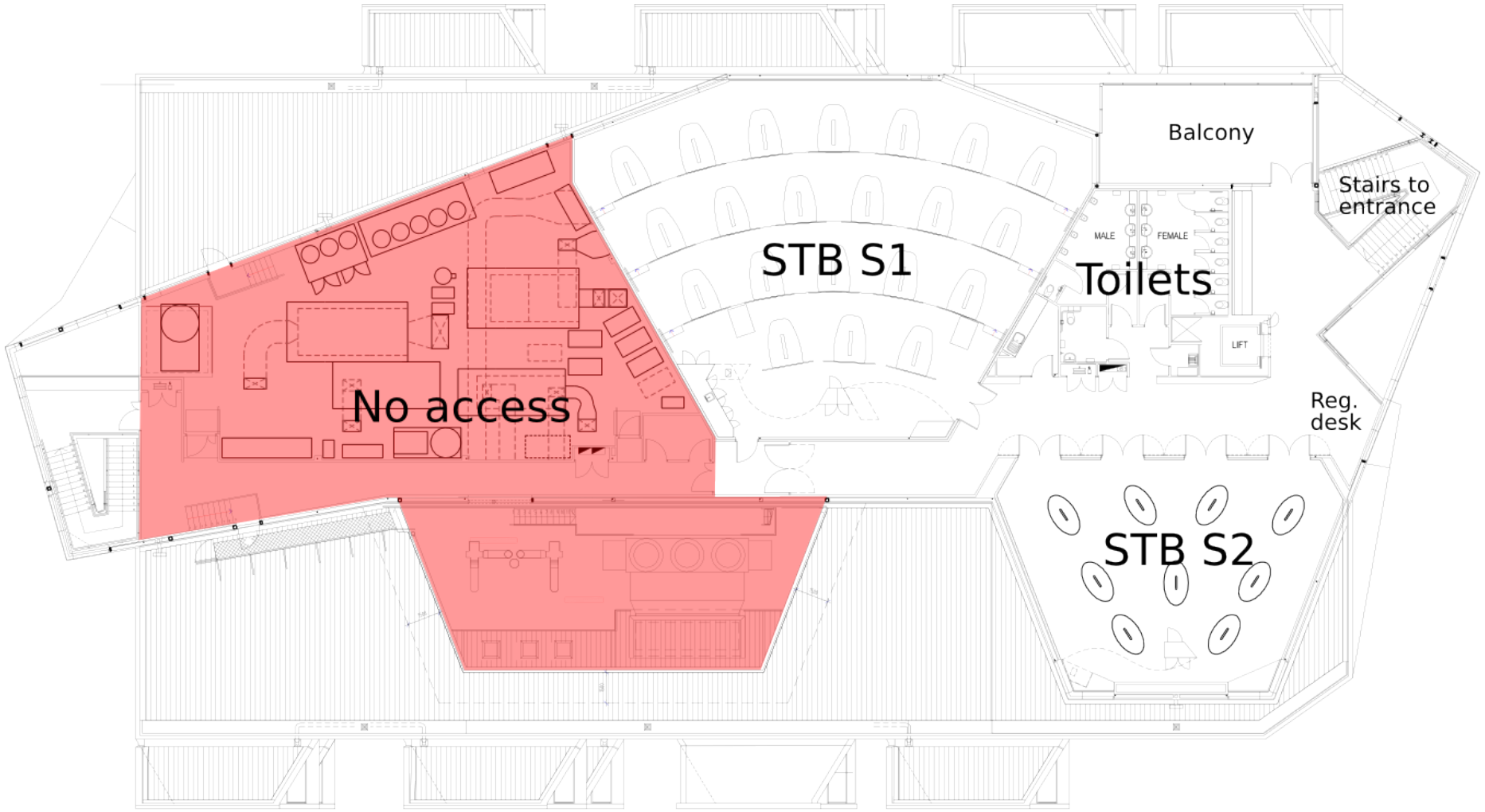

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