Table of Contents

Welcome Message

On behalf of the MTNS2018 organizing committee, I am honored and delighted to welcome all of you to the 23rd International Symposium on Mathematical Theory of Networks and Systems at the Hong Kong University of Science and Technology, Hong Kong.

Our technical program consists of 4 plenary speeches, 8 semi-plenary speeches, and 40 invited/regular sessions and mini-courses covering a wide range of research topics in mathematics, networks, and system science and engineering.

The success of the symposium couldn't be possible without the help and support from many people who have worked with us in planning and organizing both the technical program and social activities. In particular, we would like to thank the Program Chair (Graziano Chesi) for his excellent work in putting together the technical program, the other General Co-Chairs (Daniel Ho, James Lam, Guofeng Zhang, Tao Liu) and the secretary of the conference (Huan Jin) for their dedicated and professional service, the Advisory Committee (chaired by Li Qiu) and the MTNS Steering Committee for their valuable suggestions and feedback, the International Program Committee for their timely review of the papers, and our sponsors for their financial support.

Although we have tried our very best effort preparing for the symposium, we believe there is still plenty room for improvement. Please accept our sincere apologies if any inconvenience is caused and we very much appreciate if you can provide us with your valuable comments/feedback.

Finally, we hope that you will enjoy MTNS2018 and wish you a pleasant stay in Hong Kong!

Ling Shi

General Chair (MTNS2018)

History

MTNS, the International Symposium on the Mathematical Theory of Networks and Systems is a major symposium in the general area of mathematical systems theory. The symposium is interdisciplinary and attracts mathematicians, engineers and researchers working in all aspects of systems theory. The symposium is organized every two years and traditionally covers areas involving a wide range of research directions in mathematical systems, networks and control theory. Mathematical methods which play a role in the areas mentioned above stem from a broad range of fields of pure and applied mathematics, including ordinary and partial differential equations, real and complex analysis, numerical analysis, probability theory and stochastic analysis, operator theory, linear and commutative algebra as well as algebraic and differential geometry. There are a wide range of applications ranging from problems in biology, communications and mathematical finance to problems in chemical engineering, aerospace engineering and robotics.

The meetings are scheduled by an international steering committee. The twenty-two previous MTNS meetings were held in:

1973	College Park, Maryland, USA	1996	St. Louis, Missouri, USA
1975	Montreal, Canada	1998	Padova, Italy
1977	Lubbock, Texas, USA	2000	Perpignan, France
1979	Delft, the Netherlands	2002	Notre Dame, Indiana, USA
1981	Santa Monica, California, USA	2004	Leuven, Belgium
1983	Beer Sheva, Israel	2006	Kyoto, Japan
1985	Stockholm, Sweden,	2008	Blacksburg, Virginia, USA
1987	Phoenix, Arizona, USA	2010	Budapest, Hungary
1989	Amsterdam, the Netherlands	2012	Melbourne, Australia
1991	Kobe, Japan	2014	Groningen, Netherlands
1993	Regensburg, Germany	2016	Minneapolis, USA

Steering Committee

The continuity of the MTNS meetings is ensured by the MTNS Steering Committee, presently consisting of:

Athanasios C. Antoulas (USA)	Li Qiu (Hong Kong SAR)
Joseph A. Ball (USA)	Michele Pavon (Italy)
Tryphon Georgiou (USA)	Anders Rantzer (Sweden)
Heide Gluesing-Luerssen (USA)	Joachim Rosenthal (Switzerland)
Lars Grüne (Germany)	Jacquelien Scherpen (The Netherlands)
J. William Helton (USA)	Rodolphe Sepulchre (United Kingdom)
Yiguang Hong (China)	Ling Shi (Hong Kong SAR)
Birgit Jacob (Germany)	Malcolm Smith (United Kingdom)
Margreta Kuijper (Australia)	Toshiharu Sugie (Japan)
Alexander Borisovich Kurzhanski (Russia)	Arjan van der Schaft (The Netherlands)
Sanjay Lall (USA)	Victor Vinnikov (Israel)
Anders Lindquist (Sweden)	Yutaka Yamamoto (Japan)
Iven Mareels (Australia)	Yoshito Ohta (Japan)
Kirsten Morris (Canada)	Eva Zerz (Germany)
Pablo Parrilo (USA)	

Organizing Committee

- **General Chair:**

Ling Shi, Hong Kong University of Science and Technology

- **General Co-Chairs:**

Graziano Chesi, The University of Hong Kong

Daniel Ho, City University of Hong Kong

James Lam, The University of Hong Kong

Tao Liu, The University of Hong Kong

Guofeng Zhang, The Hong Kong Polytechnic University

- **Advisory Committee:**

Li Qiu, Hong Kong University of Science and Technology (**Chair**)

Xi-Ren Cao, Department of Automation, Shanghai Jiao Tong University

Jie Chen, City University of Hong Kong

Gary Feng, City University of Hong Kong

Sponsors

香港科技大學
THE HONG KONG UNIVERSITY OF SCIENCE AND TECHNOLOGY

Department of
Electronic & Computer Engineering
電子及計算機工程學系

王寬誠教育基金會
K. C. WONG EDUCATION FOUNDATION

HKUST JOCKEY CLUB
INSTITUTE FOR ADVANCED STUDY

HKACA
HONG KONG AUTOMATIC CONTROL ASSOCIATION

General Information

- **Conference Venue:**

Lecture Theatres: B, D and E *(1/F, Academic Building)*

Classrooms: 2463, 2464, 2465, 2502, 2503, 2504 *(2/F, lifts 25/26)*

5506, 5508 *(2/F, lifts 25/26)*

Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

http://www.ust.hk/

- **Registration Desk:**

At welcome reception venue: 16 July 15:30-18:30

At the hallway outside the lecture theatres:

17 July 2018: 08:30–18:00

18 July 2018: 08:30–12:00

19 July 2018: 08:30–12:00

- **Wi-Fi Service at HKUST**

1. eduroam Wi-Fi (SSID = eduroam)

Education Roaming (eduroam) is an international wireless service, which uses IEEE 802.1X technology to provide free, easy, and flexible Wi-Fi access among education institutions around the world. In case you cannot connect using your own account, please use the following information for log-in:

Username: mtnsguest

Password: hkust2018july

2. Wi-Fi.HK via HKUST (SSID = Wi-Fi.HK via HKUST)

This service is a collaboration with Hong Kong Government to promote the common Wi-Fi brand. Visitors can surf the Internet in public areas of HKUST campus. The service is free of charge and does not require any registration. In order to use this service, the users must agree to HKUST's Acceptable Usage Policy.

For more information on Wifi service, please refer to the website:

https://itsc.ust.hk/services/general-it-services/wifi/wi-fi-services/#wifihk

- **Emergency Contacts**
  - On Campus - Security Control Center
    Dial **8999** when using HKUST campus phone
    Dial **+852 2358 8999** if you are using your mobile phone

  - Off Campus - Police / Fire / Ambulance: **999**

Other numbers you may use:

Police Hotline	+852 2527 7177
Travel Industry Council of Hong Kong	+852 2807 0707
Hong Kong Tourism Board Visitor Hotline	+852 2508 1234
Hong Kong International Airport	+852 2181 8888
Hong Kong Immigration Department	+852 2824 6111
Consumer Council	+852 2929 2222
Department of Health	+852 2961 8989
Customs and Excise Department 24-Hour Hotline	+852 2815 7711
Hongkong Post	+852 2921 2222
Hong Kong Observatory (for weather information)	+852 1878 200
Telephone directory enquiries	1081

You are also welcome to seek assistance from the conference helpers.

Presentation Guidelines

In each presentation lecture theatre/classroom, the computer projector and Microsoft Window based desktop computer will be available. VGA, HDMI connection cable and a laser presenter will be provided. If other connection cables are needed, presenters need to prepare by themselves.

One student helper will be there to assist the set-up 30 mins before the session starts.

The presenters are encouraged to bring both their presentation files in USB memory sticks and their own laptop computer. Please test your presentation slides before the session starts to avoid any potential format and incompatibility problems.

Social Activities

Date & Time	Event	Venue
Monday 6-8 pm (16 July)	**Welcome reception**	**UniQue, Conference Lodge** *HKUST campus*
Wednesday 2-6 pm (18 July)	**Local tour**	*Self-arranged*
Thursday 7:30-9:30 pm (19 July)	**Banquet**	**Banqueting House** *Tsim Sha Tsui East*
Friday 6:30-8:30 pm (20 July)	**Farewell reception**	**UC Bistro** *HKUST campus*

HKUST Location Map

For more information, please refer to webpages:

http://www.ust.hk/about-hkust/about-the-campus/map-directions-2015/

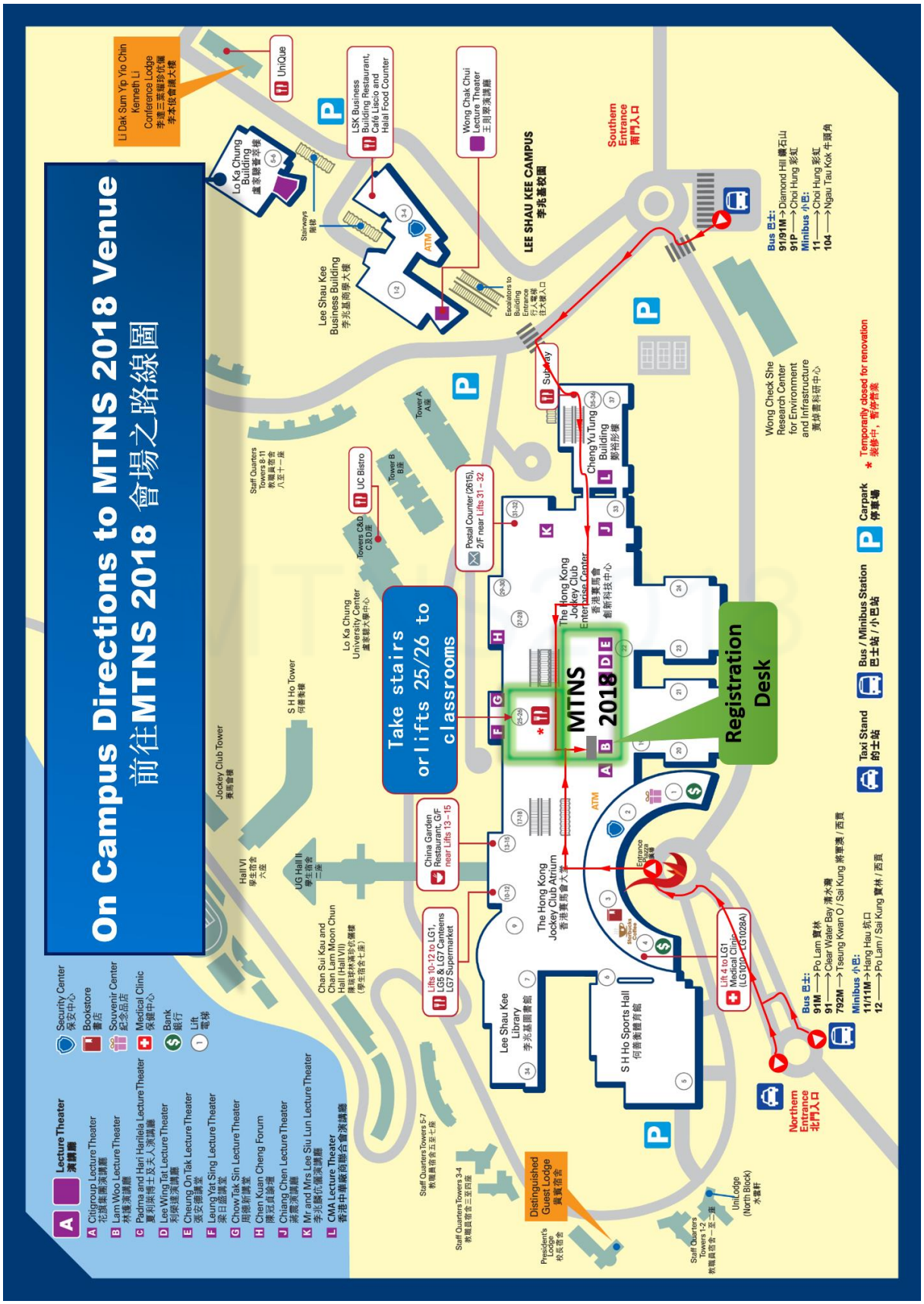
http://library.ust.hk/about-us/contact-us/transportation/

http://www.ust.hk/hkust-campus-map/

https://ptc.ust.hk/ptc/download/submenu10/index.html

Directions to Conference Venue

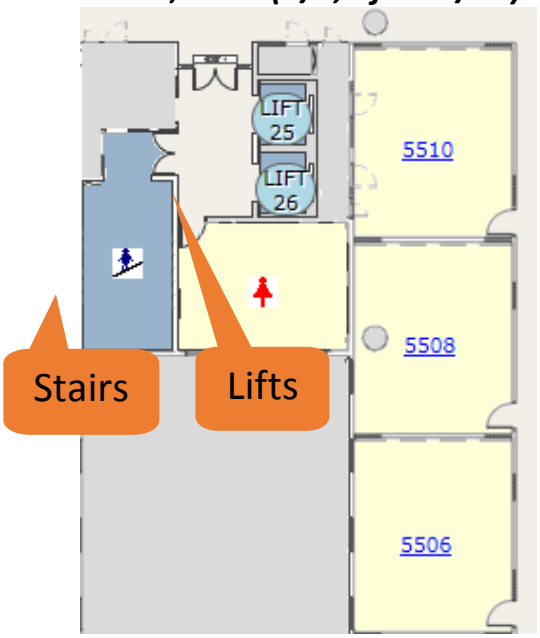
Lecture Theatres: B, D and E *(1/F, Academic Building)*



Directions to Conference Venue

Classrooms: 2463, 2464, 2465, 2502, 2503, 2504 *(2/F, lifts 25/26)*

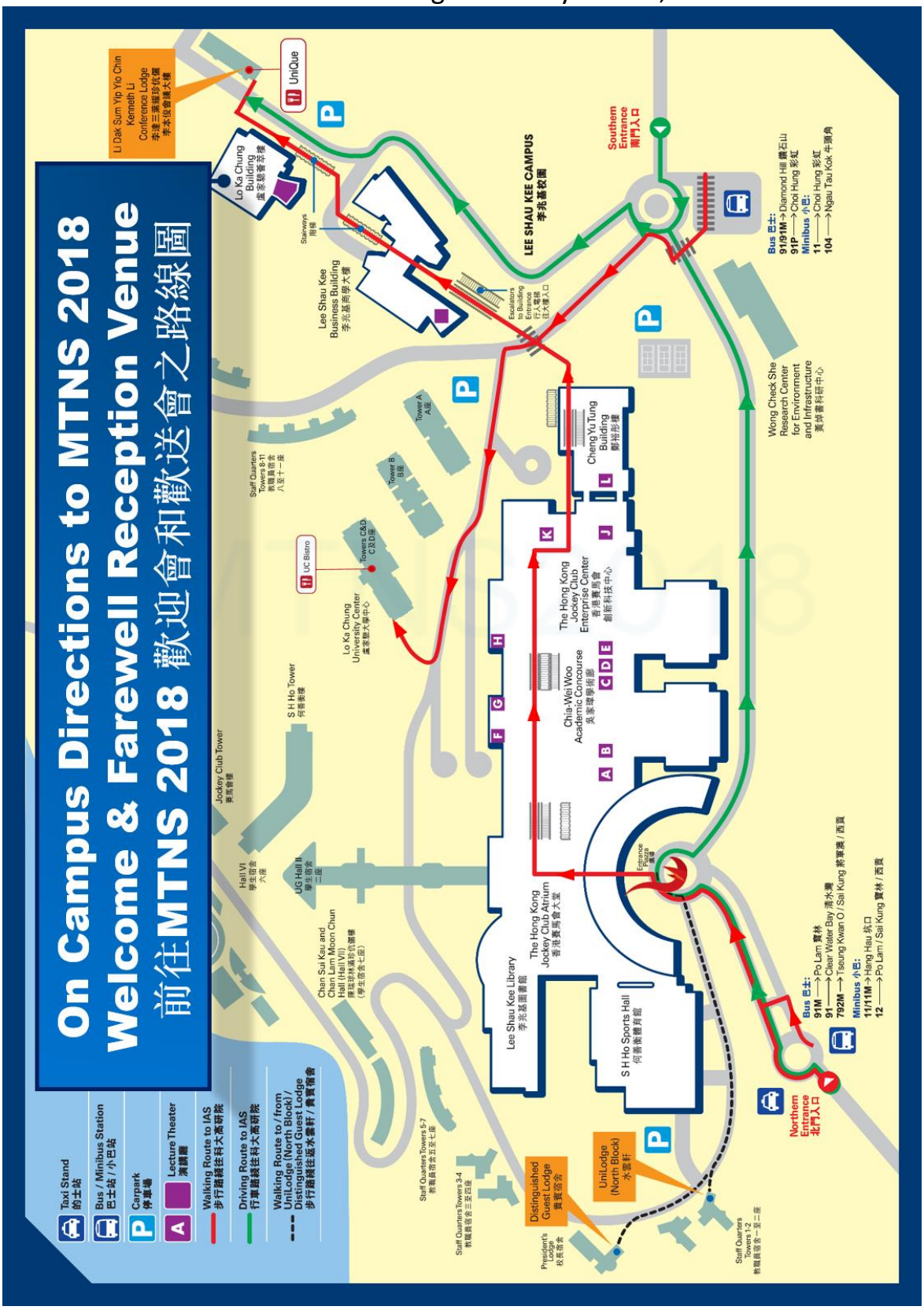
5506, 5508 *(5/F, lifts 25/26)*



Directions to Welcome and Farewell Venue

UniQue: Li Dak Sum Yip Yio Chin Kenneth Li Conference Lodge, HKUST

UC Bistro: Lo Ka Chung University Center, HKUST

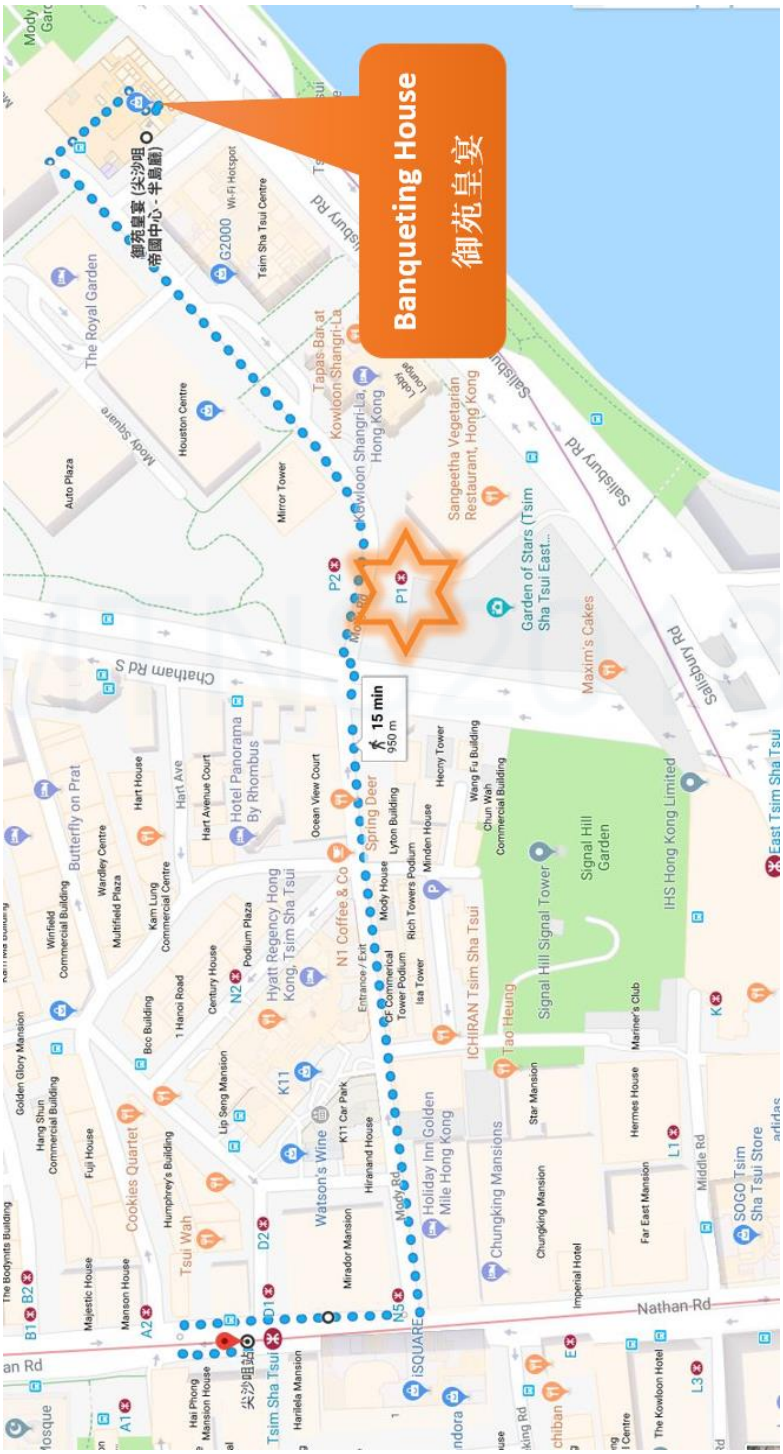


Directions to Banquet Venue

Address : Victoria Harbour Ballroom, The Banqueting House (East Tsim Sha Tsui)

1/F, Empire Centre, 68 Mody Road, Tsim Sha Tsui

(East Tsim Sha Tsui MTR Station – Exit P1)



MTNS 2018 Program at a Glance

MTNS 2018 Technical Program Tuesday July 17, 2018

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7
09:00-10:00 TuAP LTB Plenary 1: Power Network Science: Stability and Control (by David J. Hill)						
10:30-13:00 TuB1 Room 2463 Convex Algebraic Geometry I	10:30-13:00 TuB2 Room 2464 Cybersecurity of Systems	10:30-13:00 TuB3 Room 2465 Distributed Parameter Systems I	10:30-13:00 TuB4 Room 2502 Distributed Parameter Systems II	10:30-13:00 TuB5 Room 2503 Multi-Agent Coordination and Optimization	10:30-13:00 TuB6 Room 2504 Large Scale Systems	10:30-13:00 TuB7 Room 5506 Port-Hamiltonian Systems on Graphs and Complexes
14:30-15:30 TuCSP1 LTD Semi-Plenary 1: Bridging Evolution, Decision and Self-Regulation in Networked Systems (by Chiara Mocenni)				14:30-15:30 TuCSP2 LTE Semi-Plenary 2: Coverage Control on Heterogeneous Mobile Sensor Networks (by Xiaofan Wang)		
16:00-18:05 TuD1 Room 2463 Convex Algebraic Geometry II	16:00-18:05 TuD2 Room 2464 Efficiency and Security on Estimation and Control in Networks	16:00-18:05 TuD3 Room 2465 Distributed Parameter Systems III	16:00-18:05 TuD4 Room 2502 Majorization Theory and Its Applications	16:00-18:05 TuD5 Room 2503 Secure and Efficient Information Processing in Cyber-Physical Systems	16:00-18:05 TuD6 Room 2504 Algebraic Systems Theory	16:00-18:05 TuD7 Room 5506 Delay and Event Systems

MTNS 2018 Technical Program Wednesday July 18, 2018

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7
09:00-10:00 WeAP LTB Plenary 2: Network Games (by Asu Ozdaglar)						
10:30-11:30 WeBSP1 LTD Semi-Plenary 3: Exploiting Symmetry in Observer Design for Flying Robots (by Jochen Trumpf)				10:30-11:30 WeBSP2 LTE Semi-Plenary 4: Distributed Optimization and Its Application to Computation of Matrix Equations (by Yiguang Hong)		
11:45-12:30 WeTr LTB Tribute to Bruce A. Francis						

MTNS 2018 Technical Program Thursday July 19, 2018

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7
09:00-10:00 ThAP LTB Plenary 3: Going Beyond the Shannon Paradigm - a New Approach to Digital Control and Signals (by Yutaka Yamamoto)						
10:30-13:00 ThB1 Room 2463 Coding Theory: Codes and Security	10:30-13:00 ThB2 Room 2464 Positivity, Factorizations, and State Space Realizations for Scalar and Matrix Variables I	10:30-13:00 ThB3 Room 2465 Optimal Control and Hamilton-Jacobi-Bellman Equations	10:30-13:00 ThB4 Room 2502 Networked Control Systems I	10:30-13:00 ThB5 Room 2503 Nonlinear Systems and Control I	10:30-13:00 ThB6 Room 2504 Optimization I	10:30-13:00 ThB7 Room 5506 Modeling and Estimation
14:30-15:30 ThCSP1 LTD Semi-Plenary 5: Evolutionary Decision-Making Dynamics among Networks of Autonomous Agents (by Ming Cao)				14:30-15:30 ThCSP2 LTE Semi-Plenary 6: Operator Theory Approach to Quantum Error Correction (by Chi-Kwong Li)		
16:00-18:05 ThD1 Room 2463 Coding Theory: Coding and Convolutional Codes	16:00-18:05 ThD2 Room 2464 Positivity, Factorizations, and State Space Realizations for Scalar and Matrix Variables II	16:00-18:05 ThD3 Room 2465 Analysis and Synthesis of Positive Systems	16:00-18:05 ThD4 Room 2502 Input-To-State Stability of Distributed Parameter Systems	16:00-18:05 ThD5 Room 2503 Control of Distributed Parameter Systems	16:00-18:05 ThD6 Room 2504 Optimization II	16:00-18:05 ThD7 Room 5506 [Title not available]

MTNS 2018 Technical Program Friday July 20, 2018

Track 1	Track 2	Track 3	Track 4	Track 5	Track 6	Track 7
09:00-10:00 FrAP LTB Plenary 4: Stabilization of Coupled Hyperbolic PDE: Calming "Stop-And-Go" Traffic with Backstepping (by Miroslav Krstic)						
10:30-13:00 FrB1 Room 2463 Coding Theory: Coding Theory and Applications	10:30-13:00 FrB2 Room 2464 Further Developments and Applications of Multidimensional Systems	10:30-13:00 FrB3 Room 2465 Stochastic Approaches and Hamilton-Jacobi Equations	10:30-13:00 FrB4 Room 2502 Networked Control Systems II	10:30-13:00 FrB5 Room 2503 Nonlinear Systems and Control II	10:30-13:00 FrB6 Room 2504 Systems on Graphs	10:30-13:00 FrB7 Room 5506 Advances in Multi-Agent Systems
14:30-15:30 FrCSP1 LTD Semi-Plenary 7: Learning Predictive Models from Observed Network Equilibria: From Transportation to Metabolic Networks (by Yannis Paschalidis)				14:30-15:30 FrCSP2 LTE Semi-Plenary 8: The Quest for Long-Lived Quantum Bit (by Mazyar Mirrahimi)		
16:00-18:05 FrD1 Room 2463 Analysis and Control of Networked and Large-Scale Systems	16:00-18:05 FrD2 Room 2464 Linear Systems	16:00-18:05 FrD3 Room 2465 Signal Processing	16:00-18:05 FrD4 Room 2502 Networked Control Systems III	16:00-18:05 FrD5 Room 2503 Nonlinear Systems and Control III	16:00-18:05 FrD6 Room 2504 [Title not available]	16:00-18:05 FrD7 Room 5506 [Title not available]

MTNS 2018 Plenary and Semi-Plenary Lectures

Plenary lectures

Plenary 1: Power Network Science: Stability and Control (by David J. Hill)

Plenary 2: Network Games (by Asu Ozdaglar)

Plenary 3: Going Beyond the Shannon Paradigm - a New Approach to Digital Control and Signals (by Yutaka Yamamoto)

Plenary 4: Stabilization of Coupled Hyperbolic PDE: Calming “Stop-And-Go” Traffic with Backstepping (by Miroslav Krstic)

Semi-Plenary lectures

Semi-Plenary 1: Bridging Evolution, Decision and Self-Regulation in Networked Systems (by Chiara Mocenni)

Semi-Plenary 2: Coverage Control on Heterogeneous Mobile Sensor Networks (by Xiaofan Wang)

Semi-Plenary 3: Exploiting Symmetry in Observer Design for Flying Robots (by Jochen Trumpf)

Semi-Plenary 4: Distributed Optimization and Its Application to Computation of Matrix Equations (by Yiguang Hong)

Semi-Plenary 5: Evolutionary Decision-Making Dynamics among Networks of Autonomous Agents (by Ming Cao)

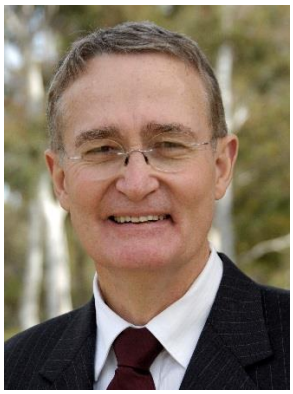
Semi-Plenary 6: Operator Theory Approach to Quantum Error Correction (by Chi-Kwong Li)

Semi-Plenary 7: Learning Predictive Models from Observed Network Equilibria: From Transportation to Metabolic Networks (by Yannis Paschalidis)

Semi-Plenary 8: The Quest for Long-Lived Quantum Bit (by Mazyar Mirrahimi)

Plenary 1: Power Network Science: Stability and Control

David J. Hill
The University of Hong Kong
https://www.eee.hku.hk/people/dhill/



Abstract: The talk will review power system theory by merging two viewpoints. Firstly and more recently, the network science viewpoint, which exploits the structural features of the power grid (or networks); and secondly, the dynamical systems viewpoint, which emphasizes the nonlinear dynamics.

It appears that the whole of the nearly 100-year old subject of power systems can be rewritten in the dynamical networks paradigm to provide new insights. Recent work in this line from engineering and science researchers has given new life to the theoretical basics of power networks, particularly in the areas of stability and distributed control. These contributions including those of the speaker will be presented.

Biography: David J. Hill received the PhD degree in Electrical Engineering from the University of Newcastle, Australia, in 1976. He holds the Chair of Electrical Engineering in the Department of Electrical and Electronic Engineering at the University of Hong Kong. He is also a part-time Professor in the Centre for Future Energy Networks at The University of Sydney, Australia. During 2005-2010, he was an Australian Research Council Federation Fellow at the Australian National University. He has held various positions at the University of Sydney since 1994 including the Chair of Electrical Engineering until 2002 and again during 2010-2013 along with an ARC Professorial Fellowship. He has also held academic and substantial visiting positions at the universities of Melbourne, California (Berkeley), Newcastle (Australia), Lund (Sweden), Munich and in Hong Kong (City and Polytechnic Universities). His general research interests are in control systems, complex networks, power systems and stability analysis. His work is now mainly on control and planning of future energy networks and basic stability and control questions for dynamic networks.

Professor Hill is a Life Fellow of the Institute of Electrical and Electronics Engineers, USA. He is a Fellow of the Society for Industrial and Applied Mathematics, USA, the Australian Academy of Science, the Australian Academy of Technological Sciences and Engineering and the Hong Kong Academy of Engineering Sciences. He is also a Foreign Member of the Royal Swedish Academy of Engineering Sciences.

Plenary 2: Network Games

Asu Ozdaglar
Massachusetts Institute of Technology
https://asu.mit.edu/

Abstract: In many social and economic settings, decisions of individuals are affected by the actions of their friends, colleagues, and peers. Examples include adoption of new products and innovations, opinion formation and social learning, public good provision, financial exchanges and international trade. Network games have emerged as a powerful framework to study these settings with particular focus on how the underlying patterns of interactions, governed by a network, affect the economic outcomes. For tractability reasons, much of the work in this area studied games with special structure (e.g., quadratic cost functions, scalar non-negative strategies) or special properties (e.g., games of strategic complements or substitutes). These works relied on disparate techniques for their analysis which then led to different focal network properties for existence and uniqueness of equilibria.

In this talk, we will present a unified framework based on a variational inequality reformulation of the Nash equilibrium to study equilibrium properties of network games including existence and uniqueness, convergence of the best response dynamics and comparative statics. Our framework extends the literature in multiple dimensions. It applies to games with strategic complements, substitutes as well as games with general strategic interactions. It provides a systematic understanding of which spectral properties of the network are relevant in establishing fundamental properties of the equilibrium. Moreover, it covers network games with multidimensional and constrained strategy sets.

This is joint work with Francesca Parise.

Biography: Asu Ozdaglar received the B.S. degree in electrical engineering from the Middle East Technical University, Ankara, Turkey, in 1996, and the S.M. and the Ph.D. degrees in electrical engineering and computer science from the Massachusetts Institute of Technology, Cambridge, in 1998 and 2003, respectively.

She is currently a professor in the Electrical Engineering and Computer Science Department at the Massachusetts Institute of Technology. She is also the director of the Laboratory for Information and Decision Systems. Her research expertise includes optimization theory, with emphasis on nonlinear programming and convex analysis, game theory, with applications in communication, social, and economic networks, distributed optimization and control, and network analysis with special emphasis on contagious processes, systemic risk and dynamic control.

Professor Ozdaglar is the recipient of a Microsoft fellowship, the MIT Graduate Student Council Teaching award, the NSF Career award, the 2008 Donald P. Eckman award of the American Automatic Control Council, the Class of 1943 Career Development Chair, the inaugural Steven and Renee Innovation Fellowship, and the 2014 Spira teaching award. She served on the Board of Governors of the Control System Society in 2010 and was an associate editor for IEEE Transactions on Automatic Control. She is currently the area co-editor for a new area for the journal Operations Research, entitled “Games, Information and Networks” and the chair of the Control System Society Technical Committee “Networks and Communication Systems”. She is the co-author of the book entitled “Convex Analysis and Optimization” (Athena Scientific, 2003).

Plenary 3: Going Beyond the Shannon Paradigm - a New Approach to Digital Control and Signals

Yutaka Yamamoto
Kyoto University
https://sites.google.com/site/yutakayamamotoen/

Abstract: Since the advent of the celebrated sampling theory by Shannon, the notion of band-limited signals have become very popular and prevalent. It shows that band-limited signals can be perfectly reconstructed from their sampled values. This fact led to the common understanding that one has to limit the signal bandwidth below the so-called Nyquist frequency to bring the digital signals into successful processing or control. This talk challenges this band-limiting principle. While the Shannon theory guarantees perfect reconstruction for perfectly band-limited signals, there are many practical situations where the basic band-limiting hypothesis is not met, due to physical or practical constraints on the sampling period. For example, the superresolution in image reconstruction, rejection of high frequency disturbance signals beyond the Nyquist frequency, etc. This requires to optimally

reconstructing intersample signals, including high frequency components.

We will show that with a suitable choice of a signal enerator model, this objective is indeed attained using robust sampled-data control theory. This can lead to many new applications in control and signal processing which were deemed impossible due to the limitation of the band-limiting hypothesis. We will show various applications in image processing, tracking/rejection of high frequency disturbance signal beyond the Nyquest frequency, e.g., in hard-disc drives, and also indicate some new areas which may lead to a new horizon of digital control and signal processing.

Biography: Yutaka Yamamoto received his B.S. and M.S. degrees in engineering from Kyoto University, Kyoto, Japan in 1972 and 1974, respectively, and the M.S. and Ph.D. degree in mathematics from the University of Florida, in 1976 and 1978, respectively. From 1978 to 1987 he was with Department of Applied Mathematics and Physics, Kyoto University. In 1987 he joined the Department of Applied Systems Science as an Associate Professor and became a professor in 1997. He had been a professor at the Department of Applied Analysis and Complex Dynamical Systems, Graduate School of Informatics of Kyoto University until 2015. He is now Professor Emeritus of Kyoto University. His research and teaching interests are in realization and robust control of distributed parameter systems, learning control systems, and sampled-data systems, its application to digital signal processing, with emphasis on sound and image processing.

He received Sawaragi memorial paper award in 1985, outstanding paper award of SICE in 1987 and in 1997, the best author award of SICE in 1990 and in 2000, the George S. Axelby Outstanding Paper Award in 1996, and the Commendation for Science and Technology by the Minister of Education, Culture, Sports, Science and Technology Prizes for Science of Technology in 2007. He received the IEEE Control Systems Society Distinguished Member Award in 2009, and the Transition to Practice Award of the Control Systems Society in 2012, as well as the ISCIE Best Industrial Paper Award in 2009. He received the Tateishi Prize of the Tateishi Science and Technology Foundation in 2015. He is a Fellow of the IEEE and IFAC and SICE.

He served as President of the IEEE Control Systems Society for 2013 and is Past President. He has served as vice President for Technical Activities of the CSS for 2005.2006, and as vice President for Publication Activities for 2007.2008. He was an associate editor of the IEEE Transactions on Automatic Control, Automatica, Systems and Control Letters, and is currently an associate editor of Mathematics of Control, Signals and Systems. He has served as a Senior Editor for the IEEE Transactions on Automatic Control for 2010.2011. He also served as an organizing committee member of 35th CDC in 1996, MTNS'91 in Kobe, and as a member of program committees of several CDC's. He was the chair of the Steering Committee of MTNS, served as General Chair ofMTNS 2006. He is a past President of ISCIE of Japan.

Plenary 4: Stabilization of Coupled Hyperbolic PDE: Calming "Stop-And-Go" Traffic with Backstepping

Miroslav Krstic
University of California, San Diego
http://flyingv.ucsd.edu/

Abstract: "Stop-and-go" traffic oscillations require multiple hyperbolic PDEs to capture correctly – as a minimum, separate density and velocity dynamics need to be included, as in the state-of-the-art Aw-Rascle-Zhang model which, unlike the previous `gas dynamics' imitations of traffic, also includes elements of human behavior ("forward-oriented" attention, collision avoidance, etc.). Instability of the stop-and-go kind arises due to the coupling in the PDEs throughout their domain. While in the far future, with fully automated freeways, control will be possible at each vehicle, allowing the PDEs to be decoupled by feedback, the means of

traffic actuation of today are located only at “boundaries,” as in the case of ramp metering at the freeway entrance. Simple collocated static feedback laws do not suffice for stabilizing PDEs that are coupled domain-wide. The domain-wide decoupling with boundary control is possible, however, using the backstepping approach, which also allows estimation of both the states and the unknown parameters of the freeway and the drivers on it, all from sensing only at the ramp. I will illustrate the theoretical/mathematical and methodological ideas for the boundary control of coupled hyperbolic PDEs within the setting of traffic control and other applications.

Biography: Miroslav Krstic is Distinguished Professor of Mechanical and Aerospace Engineering, holds the Alspach endowed chair, and is the founding director of the Cymer Center for Control Systems and Dynamics at UC San Diego. He also serves as Associate Vice Chancellor for Research at UCSD. As a graduate student, Krstic won the UC Santa Barbara best dissertation award and student best paper awards at CDC and ACC. Krstic has been elected Fellow of seven scientific societies – IEEE, IFAC, ASME, SIAM, AAAS, IET (UK), and AIAA (Assoc. Fellow) – and as a foreign member of the Academy of Engineering of Serbia. He has received the ASME Oldenburger Medal, Nyquist Lecture Prize, Paynter Outstanding Investigator Award, Ragazzini Education Award, Chestnut textbook prize, the PECASE, NSF Career, and ONR Young Investigator awards, the Axelby and Schuck paper prizes, and the first UCSD Research Award given to an engineer. Krstic has also been awarded the Springer Visiting Professorship at UC Berkeley, the Distinguished Visiting Fellowship of the Royal Academy of Engineering, the Invitation Fellowship of the Japan Society for the Promotion of Science, and honorary professorships from four universities in China. He serves as Senior Editor in IEEE Transactions on Automatic Control and Automatica, as editor of two Springer book series, and has served as Vice President for Technical Activities of the IEEE Control Systems Society and as chair of the IEEE CSS Fellow Committee. Krstic has coauthored twelve books on adaptive, nonlinear, and stochastic control, extremum seeking, control of PDE systems including turbulent flows, and control of delay systems.

Semi-Plenary 1: Bridging Evolution, Decision and Self-Regulation in Networked Systems

Chiara Mocenni
University of Siena
http://www.dii.unisi.it/~mocenni/

Abstract: The talk tackles the problem of integrating mechanisms typical of biological evolution with human decision making and dynamics over networks. Starting from the concepts of competition and cooperation in social systems, the effects of heterogeneous and nonlinear interactions among the members of a population are investigated. Standard evolutionary game equations are extended to account for the presence of connection networks, and to study the influence of topology on decision making. Moreover, self-regulating mechanisms, modeling internal processes, such as awareness and learning, are shown to induce inertial forces driving individuals towards more cooperative states. Interestingly, self-regulation produces different effects in weakly and strongly connected individuals, thus allowing to point out how meaningful are networks in human societies. This is particularly evident when analysing emergence of cooperation, for which it is possible to identify selfish and altruistic dynamic traits. Theoretical results on the stability of steady states at global and local level, including consensus over the network, are presented. Additional conclusions arising from numerical experiments are also discussed.

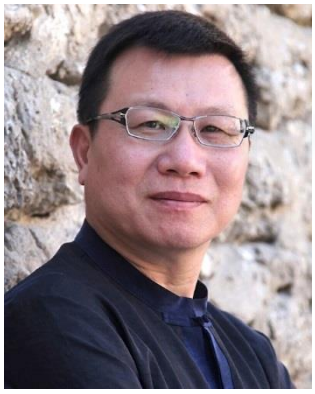
Biography: Chiara Mocenni is an associate professor of Systems and Control at the Department of Information Engineering and Mathematics (DIISM) of the University of Siena since October 2015. She teaches Game Theory and Evolutionary Games and Complex Dynamic Systems in the Courses of Management and Information Engineering of the University of Siena. Chiara Mocenni has been researcher and assistant professor at DIISM from 2002 to 2015.

She received her Laurea Degree in Mathematics from the University of Siena in 1992's. Before joining the Systems and Control Group at DII in 1998 as Research Associate, Chiara Mocenni received the PhD in Physical Chemistry defending a thesis on mathematical modeling of ecological systems.

From the 2000's until its deactivation on 2012, she has been fellow of the Center for the Study of Complex Systems of the University of Siena and served on its Board of Directors. In 2013 Chiara Mocenni founded the Complex Systems Community, a network of researchers working in the field of complex systems. From 2013 to 2016 Chiara Mocenni is Special Visiting Researcher at IMPA – Instituto Nacional de MatemÃƒ ¡tica Pura e Aplicada of Rio de Janeiro – Brazil. The research developed at IMPA concerns Evolutionary Games on Networks for Modeling Complex Biological and Socio-Economic Phenomena.

Semi-Plenary 2: Coverage Control on Heterogeneous Mobile Sensor Networks

Xiaofan Wang
Shanghai Jiao Tong University
http://cnc.sjtu.edu.cn/xfwang.html



Abstract: Cooperative control of mobile sensor networks has attracted much research interest in recent years due to its potential application such as search and environmental monitoring. This talk will focus on coverage control of mobile sensor networks on a one-dimensional space: a network of mobile sensors should distribute themselves over a one-dimensional space with the object to minimize the time cost for them to arrive at any point in the space. We first introduce the coverage control problem of networked mobile sensors on a line with non-uniform roughness by considering the different actuation constraints of the sensors. Then, the coverage control problem of a circle by a network of mobile sensors with different velocity constraints affected by measurement errors will be presented. Finally, directions for future research on coverage control will be discussed.

Biography: Xiaofan Wang received the Ph.D. degree from Southeast University, China in 1996. He has been a Professor in the Department of Automation, Shanghai Jiao Tong University (SJTU) since 2002 and a Distinguished Professor of SJTU since 2008. He received the 2002 National Science Foundation for Distinguished Young Scholars of P. R. China, the 2005 Guillemin-Cauer Best Transactions Paper Award from the IEEE Circuits and Systems Society, the 2008 Distinguished Professor of the Chaing Jiang Scholars Program, Ministry of Education, China. His current research interests include analysis and control of complex dynamical networks. He is currently the Chair of the IFAC Technical Committee on Large-Scale Complex Systems, Steering committee member of the IEEE Transactions on Network Science and Engineering (TNSE), Board member of the international Network Science Society (NetSci) and Chair of the Chinese Technical Committee on Complex Networks and System Control.

Semi-Plenary 3: Exploiting Symmetry in Observer Design for Flying Robots

Jochen Trumpf
Australian National University
http://users.cecs.anu.edu.au/~trumpf/

Abstract: S Many mechanical systems exhibit continuous symmetries that lead to dynamic models for those systems where the state space carries the structure of a homogeneous space of the symmetry Lie group. These models are prevalent in mobile robotics where such symmetries ultimately derive from the physical fact that the laws of rigid body motion are invariant to a change of reference frame.

Control theory for systems on Lie groups and homogeneous spaces is a well developed subject that has been studied since the 1970s with several popular textbooks available. In contrast, observer theory for such systems is much less developed and real progress on observer design principles for such systems has only been made in the last 10 years.

In this talk I will summarize the current state-of-the-art in observer design for kinematic systems with complete symmetries and show examples of applications of this theory to mobile robotic systems. The resulting state estimation algorithms are computationally much simpler than the alternative stochastic filters but show similar practical stability and robustness properties. Most of the observers in this talk have existing real-time implementations in on-board embedded hardware.

Biography: Jochen Trumpf received the Dipl.-Math. and Dr. rer. nat. degrees in mathematics from the University of Wuerzburg, Germany, in 1997 and 2002, respectively. He is currently an Associate Professor in the Research School of Engineering at the Australian National University. His research interests include observer theory and design, linear systems theory and optimisation on manifolds with applications in robotics, computer vision and wireless communication. He currently serves as Associate Editor for MCSS.

Semi-Plenary 4: Distributed Optimization and Its Application to Computation of Matrix Equations

Yiguang Hong
Chinese Academy of Sciences
http://lsc.amss.ac.cn/~yghong/

Abstract: In this talk, we discuss distributed optimization problems with constraints over multi-agent networks. After a brief overview, we focus on two distributed computation problems for the optimal solutions to resource allocations and to matrix equations. Distributed design for resource allocation is an important problem, which can be viewed as a constrained optimization with equality or inequality constraints. Its distributed design is quite challenging because it becomes a coupled constraint between agents. Also, we actively employ the techniques of distributed convex optimization to solve the distributed computation problem of a well-known matrix equation in several standard cases. We propose distributed gradient-based algorithms to solve them with convergence analysis.

Biography: Yiguang Hong received his B.S. and M.S. degrees from Dept of Mechanics of Peking University, China, and his Ph.D. degree from Chinese Academy of Sciences (CAS), China. He is currently the Guan Zhaozhi Professor in Academy of Mathematics and Systems Science, CAS, and serves as the Director of Key Lab of Systems and Control, CAS and the Director of the Information Technology Division, National Center for Mathematics and Interdisciplinary Sciences, CAS. His current research interests include nonlinear control, multi-agent systems, distributed optimization and game, machine learning, and social networks.

Prof. Hong serves as Editor-in-Chief of Control Theory and Technology and the president of TCCT of Chinese Association of Automation (during 2018-2022). He also serves or served as Associate Editors for many journals including IEEE Transactions on Automatic Control, IEEE Transactions on Control of Network Systems, IEEE Control Systems Magazine, and Nonlinear Analysis: Hybrid Systems. He is a recipient of Guan Zhaozhi Award at Chinese Control Conference, Young Author Prize of IFAC World Congress, Young Scientist Award of CAS, the Youth Award for Science and Technology of China, and National Natural Science Prize of China. Also, he is a Fellow of IEEE.

Semi-Plenary 5: Evolutionary Decision-Making Dynamics among Networks of Autonomous Agents

Ming Cao
University of Groningen
https://www.rug.nl/staff/m.cao/

Abstract: Whether humans in a community, fish in a school, or neurons in a brain, simple decisions or actions by interacting individuals can lead to complex and unpredictable outcomes in a population. Research on these systems at a broader scale, perhaps subject to simplification of the agent-level dynamics, can help to characterize critical properties such as convergence, stability, controllability, robustness, and performance. Correspondingly, an extensive literature has emerged in the field of evolutionary games on networks, particularly regarding the question of how cooperation can evolve and persist under various conditions and in various population structures. In this talk, I will provide a brief survey of some recent results in the analysis and control of evolutionary dynamics. In particular, I will focus on two classes of decision-making strategies, namely imitation and best-response, and show how they might lead to dramatically different collective dynamics. I will also illustrate how to apply classical tools and new ideas to control such complex dynamics.

Biography: Ming Cao is currently professor of systems and control with the Engineering and Technology Institute (ENTEG) at the University of Groningen, the Netherlands, where he started as a tenure-track assistant professor in 2008. He received the Bachelor degree in 1999 and the Master degree in 2002 from Tsinghua University, Beijing, China, and the PhD degree in 2007 from Yale University, New Haven, CT, USA, all in electrical engineering. From September 2007 to August 2008, he was a postdoctoral research associate with the Department of Mechanical and Aerospace Engineering at Princeton University, Princeton, NJ, USA. He worked as a research intern during the summer of 2006 with the Mathematical Sciences Department at the IBM T. J. Watson Research Center, NY, USA. He is the 2017 and inaugural recipient of the Manfred Thoma medal from the International Federation of Automatic Control (IFAC) for his outstanding contribution to the field of systems and control as a young researcher under 40 years old. He is the 2016 recipient of the European Control Award sponsored by the European Control Association (EUCA) for his fundamental contributions to distributed and cooperative control of multi-agent systems and complex networks. He is an associate editor for IEEE Transactions on Automatic Control, IEEE Transactions on Circuits and Systems and Systems and Control Letters, and for the Conference Editorial Board of the IEEE Control Systems Society. He is vice chair of the IFAC Technical Committee on Large Scale Complex Systems and also a member of the IFAC Technical Committee on Networked Systems. His main research interest is in autonomous robots and multi-agent systems, decision-making dynamics and complex networks.

Semi-Plenary 6: Operator Theory Approach to Quantum Error Correction

Chi-Kwong Li
College of William and Mary
http://cklixx.people.wm.edu/

Abstract: Quantum error correction is used in quantum computing to protect quantum information from errors due to decoherence and another quantum noise. Quantum error correction is essential if one has to build a quantum device to store, transmit, or process quantum information. In this talk, we will describe the mathematical framework and some recent results and problems on quantum error correction using operator theory approach.

Biography: Professor Chi-Kwong Li received his mathematics BA and PhD degrees from The University of Hong Kong. He is currently the Ferguson Professor of Mathematics at the College of William and Mary, an affiliate member of the Institute for Quantum Computing, University of Waterloo. He is a co-director of the International Research Center for Tensor and Matrix Theory at the Shanghai University in China and is a member of the scientific board of the Applied Algebra and Optimization Research Center of the Sungkyunkwan University in South Korea.

The research interest of Li is on matrix, operator theory and their applications, and he has been focusing on quantum information science in recent years. He has published more than 300 research articles. He is on editorial boards of research journals including “Linear and Multilinear Algebra” (chief editor), “Operators and Matrices” (chief editor), Linear Algebra and its Applications (senior editor).

Li has received many awards in research and teaching including 2015 JMAA Ames Awards for a recent paper in the Journal of Mathematical Analysis and Applications, the 2011 Fulbright Award, 2009 William and Mary Plumeri Award for Faculty Excellence, 2008 William and Mary Simon Teaching Prize, 2004 Virginia Outstanding Faculty Award.

Semi-Plenary 7: Learning Predictive Models from Observed Network Equilibria: From Transportation to Metabolic Networks

Yannis Paschalidis
Boston University
http://sites.bu.edu/paschalidis/

Abstract: Equilibrium modeling is common in a variety of fields such as game theory, transportation science, and cell metabolism. The inputs to these models, however, are often difficult to estimate, while their outputs, i.e., the equilibria they are meant to describe, are often directly observable. By combining ideas from inverse optimization with the theory of variational inequalities, I will present an efficient, data-driven technique for estimating the parameters of these models from observed equilibria. Our framework allows for both parametric and non-parametric estimation and provides probabilistic guarantees on the quality of the estimated quantities.

I will present applications in two seemingly distinct areas. In transportation networks we use these techniques to estimate the congestion function, which determines users’ route

selection. Using actual traffic data from the Boston area, we have been able to quantify the inefficiency of drivers' selfish behavior compared to a socially optimal solution, also called the price of anarchy.

In biochemical networks, Flux Balance Analysis (FBA) is a widely used predictive model which computes a cell's steady-state chemical reaction fluxes as a solution to an optimization problem. FBA, however, assumes a certain global cellular objective function which is not necessarily known. We will use our new method to estimate such an objective. This enables us to elucidate the cellular metabolic network control mechanisms and infer important information regarding an organism's evolution.

Biography: Yannis Paschalidis is a Professor of Electrical and Computer Engineering, Systems Engineering, and Biomedical Engineering at Boston University. He is the Director of the Center for Information and Systems Engineering (CISE). He obtained a Diploma (1991) from the National Technical University of Athens, Greece, and an M.S. (1993) and a Ph.D. (1996) from the Massachusetts Institute of Technology (MIT), all in Electrical Engineering and Computer Science. He has been at Boston University since 1996. His current research interests lie in the fields of systems and control, networks, optimization, operations research, computational biology, and medical informatics.

Prof. Paschalidis' work has been recognized with a CAREER award (2000) from the National Science Foundation, the second prize in the 1997 George E. Nicholson paper competition by INFORMS, the best student paper award at the 9th Intl. Symposium of Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks (WiOpt 2011) won by one of his Ph.D. students for a joint paper, an IBM/IEEE Smarter Planet Challenge Award, and a finalist best paper award at the IEEE International Conference on Robotics and Automation (ICRA). His work on protein docking (with his collaborators) has been recognized for best performance in modeling selected protein-protein complexes against 64 other predictor groups (2009 Protein Interaction Evaluation Meeting). His recent work on health informatics won an IEEE Computer Society Crowd Sourcing Prize. He was an invited participant at the 2002 Frontiers of Engineering Symposium organized by the National Academy of Engineering, and at the 2014 National Academies Keck Futures Initiative (NAFKI) Conference. Prof. Paschalidis is a Fellow of the IEEE and the Editor-in-Chief of the IEEE Transactions on Control of Network Systems.

Semi-Plenary 8: The Quest for Long-Lived Quantum Bit

Mazyar Mirrahimi

INRIA Paris

https://who.rocq.inria.fr/Mazyar.Mirrahimi/

Abstract: The field of quantum information processing (quantum computing and quantum communication) has seen a tremendous progress during the past few decades. Many proof-of-principle experiments on small-scale (few physical degrees of freedom) quantum systems have been realized within various physical frameworks such as NMR (Nuclear Magnetic Resonance), trapped ions, cavity quantum electrodynamics, linear optics and superconducting circuits. Despite all these achievements, and in order to make this a useful technology, a major scaling step is required towards many-qubit (quantum bit) protocols. The main obstacle here is the destruction of quantum coherence (called decoherence) due to the interaction of the quantum system with its environment. The next critical stage in the development of quantum information processing is most certainly the active quantum error correction (QEC). Through this stage, one designs, possibly using many physical qubits, an encoded logical qubit which is protected against major decoherence channels and hence admits a significantly longer effective coherence time than a physical qubit. While a theory of quantum error correction has existed and developed since mid-1990s, the first experiments are being currently investigated in the physics labs around the world. A

central challenge in all these experiments is related to real-time feedback control required for error correction. After reviewing some of the theory behind this field, I will explain how this central challenge can be attacked through passive control and dissipativity. I will also overview a series of recent experimental developments in this area.

Biography: Mazyar Mirrahimi graduated from Ecole Polytechnique, France, with a major in Applied Mathematics in 2003. He defended his PhD under the supervision of Pierre Rouchon at Mines Paristech in 2005. He was then hired as a permanent research scientist at INRIA in 2006. His initial research interests concerned nonlinear dynamical systems, geometric control and control of partial and stochastic differential equations. Later, he focused his research on quantum information and quantum control. During the period of 2005 to 2010, he collaborated with physicists in the teams of Serge Haroche at Ecole Normale Supérieure and Hideo Mabuchi at Caltech/Stanford and on various aspects of quantum measurement and quantum feedback with cavity quantum electrodynamics (QED) systems. From 2011 to 2013, he spent two years as a sabbatical visitor at the Applied Physics Department of Yale University, collaborating with the teams of Michel Devoret and Robert Schoelkopf. Through these collaborations, he has contributed to the design and analysis of various experiments on quantum error correction and quantum reservoir/dissipation engineering with superconducting circuits, giving rise to publications in high impact journals such as Nature and Science. He won “Inria-French Academy of Science young researcher award” in 2017. He is currently a director of research at INRIA, a part-time professor at Ecole Polytechnique, and a visiting scientist at Yale University. He is the leader of QUANTIC research group, a joint group between INRIA, Ecole Normale Supérieure and Mines Paristech, formed by experimental physicists and applied mathematicians.

MTNS2018 Technical Program

Technical Program for Tuesday July 17, 2018

TuB1 Room 2463

Convex Algebraic Geometry I (Invited Session)

Chair: Henrion, Didier	LAAS-CNRS
Co-Chair: Vinnikov, Victor	Ben Gurion Univ. of the Negev
Organizer: Blekherman, Gregory	Georgia Inst. of Tech
Organizer: Henrion, Didier	LAAS-CNRS
Organizer: Vinnikov, Victor	Ben Gurion Univ. of the Negev

10:30-10:55 TuB1.1

Optimal Control Problems with Oscillations, Concentrations, and Discontinuities (I), pp. 1-3

Henrion, Didier	LAAS-CNRS
Kruzik, Martin	UTIA, Acad. of Sciences of the Czech Republic
Weisser, Tillmann	LAAS-CNRS Univ. of Toulouse

Optimal control problems with oscillation (chattering controls) and concentration (impulsive controls) can have integral performance criteria such that concentration of the control signal occurs at a discontinuity of the state signal. Techniques from functional analysis (anisotropic parametrized measures) are applied to give a precise meaning of the integral cost and to allow for the sound application of numerical methods. In the oral presentation of this work, we show how this can be combined with the Lasserre hierarchy of semidefinite programming relaxations. This includes in particular the use of compactification techniques allowing for unbounded time, state and control.

10:55-11:20 TuB1.2

The Singularity Sets of a Linear Matrix Inequality in Matrix Variables (I), pp. 4-4

Helton, J. William	UC San Diego
Klep, Igor	The Univ. of Auckland
Volčič, Jurij	Ben-Gurion Univ. of the Negev

The talk will be one of 3 coordinated talks (Helton, Klep, Volčič) concerning inequalities and equalities for functions having matrix variables. Matrix multiplication does not commute, so the functions we study are typically noncommutative (nc) polynomials or rational functions. Such mathematics is central to linear systems problems which are specified entirely by a signal flow diagram and L^2 performance specs on signals. The reason being: a system connection law amounts to an algebraic operation on nc quantities, while L^2 performance constraints, through use of quadratic "storage functions", convert to matrix inequalities.

Studies of commutative polynomial inequalities are central to classical mathematics and come under the heading of Real Algebraic Geometry (RAG). Hence linear systems problems cry out for development of a noncommutative RAG. This field has developed greatly over the last decade, pushed partly by systems motivation and greatly by unfolding the parallels to classical RAG.

11:20-11:45 TuB1.3

Matrix Convexity and Noncommutative Nevanlinna-Pick Interpolation (I), pp. 5-6

Vinnikov, Victor	Ben Gurion Univ. of the Negev

Recent years saw a remarkable emergence of several general theories that are matrix or free noncommutative analogues of well established classical theories in the commutative setting. Since matrices are natural variables in many if not most problems in system theory, it is not surprising that these theories are often related to systems and control. In this talk (which is based on joint work with J. Ball and G. Marx) I will discuss a solution to the Nevanlinna-Pick interpolation problem for noncommutative functions on a matrix convex set. It is based on a general interpolation and realization theorem for noncommutative functions on generalized balls (balls defined by an arbitrary operator valued nc function) together with the description of a matrix convex set by an (in general infinite dimensional) linear matrix inequality.

11:45-12:10 TuB1.4

Symbolic Computation and Hyperbolic Polynomials (I), pp. 7-9

Simone, Naldi	Univ. De Limoges

Hyperbolic polynomials are multivariate generalizations of characteristic polynomials of real sym- metric matrices. Hyperbolic programming is the problem of computing the infimum of a linear function when restricted to the hyperbolicity cone of a hyperbolic polynomial, a generalization of semidefinite programming. In the talk I will discuss an approach based on symbolic computation, relying on the multiplicity structure of the algebraic boundary of the cone, without the assumption of determinantal representability of the given polynomial. This allows us to design exact algorithms able to certify the multiplicity of the solution and the optimal value of the linear function. This is joint work with Daniel Plaumann, University of Dortmund. In the rest of the talk, I will discuss a work in progress, joint with Rainer Sinn, FU Berlin.

TuB2 Room 2464

Cybersecurity of Systems (Invited Session)

Chair: Johansson, Karl Henrik	Royal Inst. of Tech
Co-Chair: Kuijper, Margreta	Univ. of Melbourne
Organizer: Chong, Michelle Siu Tze	KTH Royal Inst. of Tech
Organizer: Johansson, Karl H.	KTH Royal Inst. of Tech
Organizer: Kuijper, Margreta	Univ. of Melbourne

10:30-10:55 TuB2.1

On Stealthiness of Zero-Dynamics Attacks against Uncertain Nonlinear Systems: A Case Study with Quadruple-Tank Process (I), pp. 10-17

Park, Gyunghoon	Seoul National Univ
Lee, Chanhwa	Seoul National Univ
Shim, Hyungbo	Seoul National Univ

This paper studies the problem of constructing a zero-dynamics attack on “nonlinear and uncertain” cyber-physical systems being of non-minimum phase, particularly for the case of the quadruple-tank process. In most of the previous works, the zero-dynamics attack is usually designed by linearizing the nonlinear system at an operating point. As a consequence, the stealthiness of the attack may be easily violated whenever the plant has even small model uncertainty or the state trajectory under the attack moves too far from the operating point (so that the linearization is not accurate enough). Without relying on the linearization of the plant at all, in this paper we propose a nonlinear zero-dynamics attack based on the Byrnes-Isidori normal form representation. In particular, it is shown via the Lyapunov analysis that the proposed attack for the quadruple-tank process always remains stealthy until some of the tanks become empty or overflow even in the presence of small parametric uncertainty, which cannot be ensured by the existing methods. Simulation results are presented to verify the performance of the proposed attack.

10:55-11:20 TuB2.2

Attack Correction for Noise-Free Linear Systems Subject to Sensor Attacks (I), pp. 18-21

Tang, Zhanghan	The Univ. of Melbourne
Kuijper, Margreta	Univ. of Melbourne
Chong, Michelle Siu Tze	KTH Royal Inst. of Tech
Mareels, Iven	The Univ. of Melbourne
Leckie, Christopher	Univ. of Melbourne

We address the problem of attack detection and attack correction for multi-output discrete-time linear time-invariant systems under sensor attacks. More specifically, we focus on the situation where adversarial attack signals are added to some of the system's output signals. A `security index' is defined to characterize the vulnerability of a system against such sensor attacks and methods are given to calculate this index for various system representations. Algorithms are presented to detect and correct for sensor attacks on a noise-free linear system.

11:20-11:45 TuB2.3

Security Analysis of Quantized Bayesian Estimators (I), pp. 22-25

Farokhi, Farhad	The Univ. of Melbourne
Selvaratnam, Daniel D.	The Univ. of Melbourne
Shames, Iman	Univ. of Melbourne

Security of networked Bayesian source localization algorithms is analysed in this paper. The Bayesian estimators construct the probability density function of the location of the source from quantized measurements. Understanding fundamental limits in the performance of an adversary for manipulating the posterior of the Bayesian estimator is the main focus of the paper. The analysis is performed for cases where the estimator is not aware of the presence of the adversary. The results are then generalized to the case where the estimator is aware of the attacker.

11:45-12:10 TuB2.4

Secure Estimation for Linear Time-Varying Process Via Local Estimators (I), pp. 26-29

Xu, Liang	Nanyang Tech. Univ
Liu, Xinghua	Nanyang Tech. Univ
Mo, Yilin	Nanyang Tech. Univ

We are interested in the secure estimation problem of a linear time-varying Gaussian process. m sensors are deployed to measure the process state and p out of m sensors might undergo integrity attack, which means their measurements can be arbitrarily manipulated by attackers. We first show that the Kalman filter can be decomposed into m local estimators and then summed up to obtain the Kalman estimate. Then we show a least square interpretation to the fusion process and based on which a convex optimization based secure estimation scheme is proposed. The secure estimation algorithm guarantees that when all the sensors are benign, the secure estimate coincides with the Kalman filter. When less than half of the sensors are compromised, the secure estimation scheme can still generate an estimate with bounded error. In the end, numerical simulations are conducted to verify the effectiveness of the proposed algorithm.

12:10-12:35 TuB2.5

Privacy-Aware Minimum Error Probability Estimation: An Entropy Constrained Approach (I), pp. 30-33

Nekouei, Ehsan	KTH Royal Inst. of Tech
Skoglund, Mikael	Royal Inst. of Tech
Johansson, Karl Henrik	Royal Inst. of Tech

This paper studies the design of an optimal privacy-aware estimator for a single sensor estimation problem. The sensor's measurement is a (possibly non-linear) function of a private random variable, a public random variable and the measurement noise. Both public and private random variables are assumed to be discrete valued, and the measurement noise is arbitrarily distributed. The sensor provides an estimate of the public random variable for an untrusted entity, named the cloud. The objective is to design the estimator of the public random variable such that a level of privacy for the private random variable is guaranteed. The privacy metric is defined as the discrete conditional entropy of the private random variable given the output of the estimator. A binary loss function is considered for the estimation of the public random variable. The optimal estimator design problem is posed as the minimization of the average loss function subject to a constraint on the privacy level of the private random variable. It is shown that the objective function is linear and the privacy constraint is convex in the optimization variables. Thus, the optimal privacy-aware estimator can be designed by solving an infinite dimensional convex optimization problem.

12:35-13:00 TuB2.6

Unsupervised Adversarial Anomaly Detection Using One-Class Support Vector Machines (I), pp. 34-37

Weerasinghe, Prameesha Sandamal	Univ. of Melbourne
Erfani, Sarah Monazam	Univ. of Melbourne
Alpcan, Tansu	The Univ. of Melbourne
Leckie, Christopher	Univ. of Melbourne
Kuijper, Margreta	Univ. of Melbourne

Anomaly detection discovers regular patterns in unlabeled data and identifies the non-conforming data points, which in some cases are the result of malicious attacks by adversaries. Learners such as One-Class Support Vector Machines (OCSVMs) have been successfully used in anomaly detection, yet their performance may degrade significantly in adversarial conditions such as integrity attacks. This work focuses on integrity attacks, where the adversary distorts the training data in order to successfully avoid detection during evaluation. This paper presents a unique combination of anomaly detection using (1) OCSVMs in the presence of adversaries who distort training data in a targeted manner and (2) nonlinear randomized kernel methods, which facilitate computational and conceptual simplification through dimension reduction. We theoretically analyze the effects of adversarial distortions on the separating margin of OCSVMs and provide supporting empirical evidence. The proposed approach introduces a layer of uncertainty on top of the OCSVM learner, making it challenging for the adversary to guess the specific configuration of the learner.

TuB3 Room 2465

Distributed Parameter Systems I (Invited Session)

Chair: Jacob, Birgit	Bergische Univ. Wuppertal
Co-Chair: Hu, Weiwei	Oklahoma State Univ
Organizer: Jacob, Birgit	Bergische Univ. Wuppertal
Organizer: Demetriou, Michael A.	Worcester Pol. Inst
Organizer: Morris, Kirsten A.	Univ. of Waterloo

10:30-10:55 TuB3.1

Input-To-State Stability of Nonlinear Parabolic PDEs with Dirichlet Boundary Disturbances (I), pp. 38-44

Mironchenko, Andrii	Univ. of Passau
Karafyllis, Iasson	National Tech. Univ. of Athens
Krstic, Miroslav	Univ. of California at San Diego

We introduce a monotonicity-based method for studying input-to-state stability (ISS) of nonlinear parabolic equations with boundary inputs. We first show that a monotone control system is ISS if and only if it is ISS w.r.t. constant inputs. Then we show by means of classical maximum principles that nonlinear parabolic equations with boundary disturbances are monotone control systems.

With these two facts, we establish that ISS of the original nonlinear parabolic PDE with constant textit{boundary disturbances} is equivalent to ISS of a closely related nonlinear parabolic PDE with constant textit{distributed disturbances} and zero boundary condition. The last problem is conceptually much simpler and can be handled by means of various recently developed techniques.

10:55-11:20 TuB3.2

Mixed Guidance Policies of Mobile Agents in the Cooperative Estimation of Spatially Distributed Processes in Hazardous Environments (I), pp. 45-50

Demetriou, Michael A. Worcester Pol. Inst

The guidance of mobile sensor-agents used in the estimation of spatially distributed processes often neglects the effects of the process itself on the health and reliability of the sensor. When the spatially distributed process negatively impacts the health status and functionality of the sensing devices then the standard gradient-based sensor guidance will accelerate the demise of the sensor and negatively impact the performance of the estimator. A mixed policy that takes into account the cumulative effects of the environment on the health status of the sensing devices will provide a compromise between sensor functionality and estimator performance. This work considers a mixed policy where initially an information-sensitive guidance policy is implemented. Using performance-based criteria, the sensor guidance switches to an information-neutral policy and when certain thresholds pertaining to the life expectancy of the sensing devices are exceeded, then the guidance policy switches to an information-averse policy. The proposed mixed-guidance policy is demonstrated with a 2D advection-diffusion partial differential equation.

11:20-11:45 TuB3.3

On Well-Posedness & Approximation of Composite Systems (I), pp. 51-56

Cliff, Eugene M. Virginia Tech
Burns, John A Virginia Tech

In this paper we consider some issues in modeling and approximation of composite control systems defined by coupled partial differential equations and ordinary differential equations. Although these systems are motivated by applications to thermal management systems, the fundamental issues occur in many hybrid systems of subsystems. We establish a well-posedness result and provide a short discussion of how the problem formulation can impact the choice of a specific numerical approximation. In particular, the form of the coupling can impact the choice of finite volume, finite element or higher order schemes and their convergence properties. Examples are given to illustrate the ideas.

11:45-12:10 TuB3.4

Direct Method to H-Infinity Optimal Control and Algorithm Improvements (I), pp. 57-59

Lidstrom, Carolina Lund Univ
Morris, Kirsten A. Univ. of Waterloo
Rantzer, Anders Lund Univ

We address H-infinity control of a class of systems governed by parabolic partial differential equations (PDEs). Closed-form expressions for optimal state feedback with full information are stated. Unlike traditional methods for H-infinity-controller synthesis, no iteration is needed to obtain the optimal controller and a closed form expression for the controller is readily calculated. These results are used in improvements to general purpose algorithms for calculating H-infinity control for PDEs and large-scale systems.

12:10-12:35 TuB3.5

An Approximating Control Design for Optimal Mixing by Stokes Flows (I), pp. 60-63

Hu, Weiwei Oklahoma State Univ

We consider an approximating control design for optimal mixing of a non-dissipative scalar field in unsteady Stokes flows. The objective of our approach is to achieve optimal mixing at a given final time, via an active control of the flow velocity through boundary inputs. Due to the zero diffusivity of the scalar field, establishing the well-posedness of its Gaeaux derivative requires high regularity on velocity field. This condition results in the need to penalize the time derivative of the boundary control in the cost functional. As a result, the optimality system becomes difficult to solve. Our current approximating approach will provide a more transparent optimality system, with the set of admissible controls being L2 in both time and space. This is achieved by first introducing a small diffusivity to the scalar equation and then establishing a rigorous analysis of convergence of the approximating control problem to the original one as the diffusivity approaches to zero. Uniqueness of the optimal solution is obtained for the two dimensional case.

12:35-13:00 TuB3.6

Input-To-State Stability of Unbounded Bilinear Control Systems (I), pp. 64-65

Jacob, Birgit Bergische Univ. Wuppertal
Schwenninger, Felix Leopold Univ. of Hamburg

We study input-to-state stability of bilinear control system with possibly unbounded control operator and unbounded bilinearity. We show that every internally exponentially stable bilinear control system is integral input-to-state stable. An application to the bilinearly controlled Fokker-Planck equation is given.

TuB4 Room 2502

Distributed Parameter Systems II (Invited Session)

Chair: Gruene, Lars Univ. of Bayreuth
Co-Chair: Kang, Wen Univ. of Science and Tech. Beijing
Organizer: Jacob, Birgit Bergische Univ. Wuppertal
Organizer: Demetriou, Michael A. Worcester Pol. Inst
Organizer: Morris, Kirsten A. Univ. of Waterloo

10:30-10:55 TuB4.1

Distributed Delayed Stabilization of Korteweg-De Vries-Burgers Equation under Sampled in Space Measurements (I), pp. 66-71

Kang, Wen Univ. of Science and Tech. Beijing
Fridman, E. M. Tel-Aviv Univ

We consider distributed stabilization of 1-D Korteweg-de Vries-Burgers (KdVB) equation in the presence of constant input delay. The delay may be uncertain, but bounded by a known upper bound. On the basis of spatially distributed point measurements, we design a regionally stabilizing controller applied through distributed in space shape functions. The existing Lyapunov-Krasovskii functionals for heat equation that depend on the state derivative are not applicable to KdVB equation because of the third spatial derivative. We suggest a new Lyapunov-Krasovskii functional that leads to regional stability conditions of the closed-loop system in terms of linear matrix inequalities (LMIs). By solving these LMIs, an upper bound on delay that preserves regional stability can be found, together with an estimate on the set of initial conditions starting from which the state trajectories of the system are exponentially converging to zero. This estimate includes a priori Lyapunov- based bounds on the solutions of the open-loop system on the initial time interval of the length of delay. A numerical example illustrates the efficiency of the method.

10:55-11:20 TuB4.2

Robust Output Feedback Regulation for Infinite-Dimensional Systems (I), pp. 72-77

xu, Xiaodong Univ. of Alberta
Dubljevic, Stevan Univ. of Alberta

In this paper, a robust output regulation problem is considered for general infinite-dimensional systems. More precisely, for the design of the regulator, the controlled output $y(t)$ and the reference signal $y_r(t)$ are assumed to be available. One mode of the designed regulator is driven by the tracking error $e_y(t)$ and is used for the reference signal tracking and disturbance rejection, while another mode driven by $y(t)$ is used to address the plant stabilization. In particular, simpler and sufficient conditions are provided for injection

and feedback gains. The robustness is achieved based on Internal Model Principle and verified for non-destabilizing system with model uncertainties and simultaneous satisfaction of ${cal G}-$conditions is guaranteed. An uncertain hyperbolic PDE system is used to demonstrate the paper results.

11:20-11:45 TuB4.3

Source Estimation for First Order Time-Varying Hyperbolic Systems (I), pp. 78-84

Fischer, Ferdinand — Univ. Erlangen-Nürnberg
Deutscher, Joachim — Univ. Erlangen-Nürnberg
Laleg, Taous-Meriem — KAUST

This paper proposes a new method for the estimation of an in-domain source of a first order time-varying hyperbolic system. This system description is used to model the heat transfer in solar collectors where the source depends on the solar irradiance intensity and the collector's properties. The proposed method is based on the modulating functions approach. With this, the estimation problem is transformed into an algebraic system of equations. A detailed derivation of the resulting source estimation equations is given. Necessary conditions on the modulating functions for the solvability of this system of equations are also provided. Different test cases are presented to assess the performance of the proposed method.

11:45-12:10 TuB4.4

Weighted Pseudoinverse of Compact Operators and Differentiation of Signals with Random Noise (I), pp. 85-92

Zhuk, Sergiy — IBM

The paper presents a new algorithm which ``differentiates'' noisy signals with values in a Hilbert space. The algorithm provides an iterative estimation procedure which converges to the weighted pseudoinverse of a compact operator with (possibly unbounded) linear weighting operator for a wide class of signals. The case of differentiation of 1D signals corrupted by a random noise with uncertain but bounded second moments is studied in details.

12:10-12:35 TuB4.5

Sensitivity Analysis of Optimal Control Motivated by Model Predictive Control (I), pp. 93-96

Gruene, Lars — Univ. of Bayreuth
Schaller, Manuel — Univ. of Bayreuth
Schiela, Anton — Univ. of Bayreuth

We analyze the sensitivity of the extremal equations that arise when concluding first order optimality conditions for time dependent optimization problems. More specifically, we consider parabolic PDEs with a linear quadratic performance criterion. We prove the solutions boundedness with respect to the right-hand side of the first order optimality condition which includes initial data. As a consequence, it can be shown that the influence of a perturbation at a certain time decays exponentially in the temporal distance to the time of perturbation. Moreover, a quantitative turnpike theorem can be derived.

12:35-13:00 TuB4.6

Estimation of Infinite-Dimensional Systems with Unknown Disturbances (I), pp. 97-100

Morris, Kirsten A. — Univ. of Waterloo

For many problems of estimation there are disturbances other than Gaussian noise. Also, for many applications only some aspect of the state needs to be estimated, not the whole state. In an H_infty estimation approach the aim is to reduce the estimation error over all disturbances. A derivation of H_infty-output estimation in the infinite-dimensional setting is provided. A framework for calculation using finite-dimensional approximations is described. Output estimation is compared with a Kalman filter for an example with disturbances.

TuB5 — Room 2503

Multi-Agent Coordination and Optimization (Invited Session)

Chair: Tang, Yutao — Beijing Univ. of Posts and Telecommunications
Co-Chair: Deng, Zhenhua — Central South Univ
Organizer: Tang, Yutao — Beijing Univ. of Posts and Telecommunications
Organizer: Deng, Zhenhua — Central South Univ

10:30-10:55 TuB5.1

Optimal Steady-State Regulation of Multi-Agent Systems with Embedded Technique (I), pp. 101-103

Tang, Yutao — Beijing Univ. of Posts and Telecommunications
Zhu, Hao — Beijing Univ. of Posts and Telecommunications

In this paper, we study an optimal steady-state regulation problem of a multi-agent network with agents of high-order dynamics. This problem can be taken as an extended version of the existing steady-state regulation problem for higher-order agents but with a distributed optimization requirement, where the state variables of agents are driven to the optimal solution of a global cost function in a cooperative way. To solve this problem, we first construct an optimal signal generator, and then employed an embedded control scheme by embedding the generator in the feedback loop to obtain the final distributed control laws. Several kinds of control laws are given with different information under standard assumptions to show the effectiveness of this embedded technique.

10:55-11:20 TuB5.2

Distributed Continuous-Time Algorithm to Solve a Linear Matrix Equation (I), pp. 104-106

Deng, Wen — Univ. of Chinese Acad. of Sciences; Acad. of Mathematic
Zeng, Xianlin — Beijing Inst. of Tech
Hong, Yiguang — Chinese Acad. of Sciences

This paper studies the distributed computation of a linear matrix equation over multi-agent networks from an optimization perspective. In the problem formulation, each agent only knows its own matrices and communicates with its neighbors. Then, a distributed continuous-time algorithm is proposed for solving its least squares solution from a distributed constrained optimization viewpoint. With help of the Lyapunov stability and semi-stability analysis, we prove the convergence of the algorithm for any initial condition.

11:20-11:45 TuB5.3

Distributed Resource Allocation Algorithm for Disturbed Multi-Agent Systems Over Weight-Balanced Digraphs (I), pp. 107-110

Li, Shiling — Central South Univ
Deng, Zhenhua — Central South Univ
Nian, Xiaohong — Central South Univ

In this paper, a distributed resource allocation problem is investigated for disturbed continuous-time multi-agent systems, where the communication among agents is depicted by strongly connected and weight-balanced digraphs. A distributed continuous-time algorithm is developed based on internal model principle, and the algorithm can ensure the multi-agent systems exponentially converge to the optimal allocation even in the presence of external disturbance.

11:45-12:10 TuB5.4

Containment of Second-Order Multi-Agent Systems with Disturbances under Independent Position and Velocity Topologies (I), pp. 111-113

Zhang, Xuxi — Harbin Engineering Univ
Liu, Xianping — Harbin Engineering Univ

This paper considers containment control problem for second-order multi-agent systems with disturbances generated from linear exosystems and nonlinear exosystems, respectively, under independent position and velocity topologies. Firstly, for the case that the disturbances are generated from linear exosystems, linear disturbance observer and control protocol are proposed for each follower using the relative states among neighboring agents; Secondly, for the case that the disturbances are generated from nonlinear exosystems, based on dynamic-gain technique, nonlinear disturbance observer and control protocol are provided, under which all the followers are driven to the convex hull spanned by the leaders.

12:10-12:35 TuB5.5

Distributed Saddle-Point Seeking Via Continuous-Time Multi-Agent Systems (I), pp. 114-115

Yang, Shaofu Southeast Univ

We presents a continuous-time multi-agent system for distributed saddle-point seeking subject to bounded constraints. In the system, two groups of agents are employed for computing the two state vectors in a saddle-point, respectively. Each agent seeks for consensus with the agents in the same group, and simultaneously optimize its local objective functions by competing with the agents in the opposite group. A projection operator is introduced into the dynamics of each agent for dealing with bounded constraints. Two types of local interactions are considered. First, we consider proportional consensus protocols only. In this case, the gradient term of each agent is equipped with a disminishing gain. Second, we consider proportional-integral consensus protocols but without diminishing gain. In both cases, it is shown that the proposed systems can converge to the saddle-point set of a convex-concave function provided the communication topology is undirected and connected.

12:35-13:00 TuB5.6

Resource Management for LTE-U Based Small Cell Systems (I), pp. 116-119

Yin, Rui Zhejiang Univ. City Coll
Zhang, Yanqiong Zhejiang Gongshang Univ
Dai, Wenzhan Zhejiang Sci-Tech. Univ

To utilize the limited licensed frequency spectrum sufficiently, small cellular systems (SCY)s have been deployed to realize the spectrum reuse on licensed bands between the small base stations (SBS)s and macro base station (MBS). To further assist the transmission on licensed bands, the SBSs are also allowed to share the unlicensed bands with Wi-Fi systems, which is named as LTE-U based SBS. One of the critical challenges for the LTE-U system is how to deal with impact to the existing Wi-Fi users and ensure harmonious coexistence. In this paper, we propose one distributed and one decentralized resource management scheme for the LTE-U based SCYs to maximize the SE on licensed bands and guarantee harmonious coexistence with Wi-Fi systems on unlicensed bands, while satisfying SUEs' and MUEs' quality of service requirement. For the distributed scheme, there is not information exchange between the MBS and SBSs. On the contrary, for the decentralized scheme, there exist a limited interaction between the MBS and SBSs based on the backhaul resource constraint.

TuB6 Room 2504

Large Scale Systems (Regular Session)

Chair: Imura, Jun-ichi Tokyo Inst. of Tech
Co-Chair: Pates, Richard Lund Univ

10:30-10:55 TuB6.1

Graphon-LQR Control of Arbitrary Size Networks of Linear Systems, pp. 120-127

Gao, Shuang McGill Univ
Caines, Peter E. McGill Univ

To achieve control objectives for extremely complex and very large scale networks using standard methods is essentially intractable. In this paper, we exploit our previously proposed graphon control methodology to approximately regulate complex network systems by the use of graphon theory and the theory of infinite dimensional systems. Conditions on the exact controllability and the approximate controllability on graphon dynamical systems are investigated. Approximation schemes to approximately regulate large network systems with linear quadratic cost are developed. The convergence properties of the approximation schemes are proved. Finally, two simulations of the application of graphon-LQR control to complex networks are presented.

10:55-11:20 TuB6.2

Quantitative Analysis of Controller Design Localizability, pp. 128-133

Urata, Kengo Tokyo Inst. of Tech
Ishizaki, Takayuki Tokyo Inst. of Tech
Imura, Jun-ichi Tokyo Inst. of Tech

In this paper, we propose an index of the localizability for the distributed design of local controllers. We consider the case where a large-scale system is controlled by a retrofit controller. The retrofit controller is a local plug-in controller such that, rather than an entire system model, only a model of the subsystem of interest is required for the controller design. In addition, the retrofit controller guarantees robust stability in the sense that the control system is stable for any variations of subsystems other than the subsystem of interest, as long as the entire system before retrofit control is stable. The localizability index is defined as the $Hcal_{infty}$ norm of an error system defined based on the isolation of the subsystem of interest from the entire system. The proposed index measures how much the control performance of the subsystem of interest is invariant with respect to the variation of subsystems other than the subsystem of interest. Then, we show that the localizability index is estimated from only the model parameters of the subsystem of interest. Finally, a retrofit controller placement problem for power systems is analyzed by the localizability index.

11:20-11:45 TuB6.3

On Influencing Opinion Dynamics Over Finite Time Horizons, pp. 134-141

Kumar, Bhumesh Iit B
Sahasrabudhe, Neeraja IISER Mohali
Moharir, Sharayu Arun Indian Inst. of Tech. Bombay

In this work, we focus on strategies to influence the opinion dynamics of a well-connected society. We propose a generalization of the popular voter model. This variant of the voter model can model a wide range of individuals including strong-willed individuals whose opinion evolution is independent of their neighbors as well as conformist individuals who tend to adopt the opinion of the majority. Motivated by political campaigns which aim to influence opinion dynamics by the end of a fixed deadline, we focus on influencing strategies for finite time horizons. We characterize the nature of the optimal influencing strategies as a function of the nature of individuals forming the society. Using this, we show that for a society consisting of strong-willed individuals, the optimal strategy is to influence towards the end of the finite time horizon, whereas, for a society consisting of individuals who are affected by their peers, it could be optimal to influence in the initial phase of the finite time horizon.

11:45-12:10 TuB6.4

Damping, Inertia, and Delay Robustness Trade-Offs in Power Systems, pp. 142-145

Pates, Richard Lund Univ
Mallada, Enrique Johns Hopkins Univ

Electro-mechanical oscillations in power systems are typically controlled by simple decentralised controllers. We derive a formula for computing the delay margin of such controllers when the power system is represented by a simple mechanical network. This formula reveals a clear trade-off between system damping, inertia, and robustness to delays. In particular, it shows that reducing system

inertia, which is a common consequence of increased renewable generation, can reduce robustness to unmodelled dynamics.

12:10-12:35 TuB6.5

Asynchronous Distributed Parametric Learning with Streaming Data, pp. 146-149

Liu, Ji — Stony Brook Univ
Liu, Yang — Harvard Univ
Chen, Wei — The Hong Kong Uni. of Sci. and Tech

This extended abstract presents an asynchronous algorithm to solve a class of distributed parametric learning problems in a multi-agent network. Each agent acquires its private streaming data to establish a local learning model at times determined by its own clock. It is not assumed that the agents' clocks are synchronized or that the “event times” at which any one agent updates its variables are evenly spaced. The goal is for each agent to converge to a common global learning model, defined as the average of all local ones, by communicating only with its neighbors. It is shown that the algorithm solves the asynchronous distributed parametric learning problems almost surely, or at least with high probability, for any repeatedly jointly strongly connected sequence of neighbor graphs defined on the merged sequence of all agents' event times.

12:35-13:00 TuB6.6

Modeling Collective Behaviors: A Moment-Based Approach, pp. 150-153

Zhang, Silun — KTH Royal Inst. of Tech. Sweden
Ringh, Axel — KTH Royal Inst. of Tech
HU, XIAOMING — KTH Royal Inst. of Tech
Karlsson, Johan — Royal Inst. of Tech. (KTH)

In this note we introduce a new approach for modeling and analyzing collective behavior of a group of agents using moments. We represent the group of agents by their moments and show how the dynamics of the moments can be modeled. Then approximate trajectories of the moments can be computed and an inverse problem is solved to recover macro-scale properties of the group of agents. To illustrate the theory, a numerical example with interactions between the agents is given.

TuB7 — Room 5506

Port-Hamiltonian Systems on Graphs and Complexes (Mini-course session)

Chair: van der Schaft, Arjan J. — Univ. of Groningen
Co-Chair: Maschke, Bernhard — Univ. Claude Bernard of Lyon
Organizer: Kotyczka, Paul — Tech. Univ. München
Organizer: Maschke, Bernhard — Univ. Claude Bernard of Lyon
Organizer: van der Schaft, Arjan J. — Univ. of Groningen

10:30-13:00 TuB7

Port-Hamiltonian Systems on Graphs and Complexes, pp. 154-157

Kotyczka, Paul — Tech. Univ. München
Maschke, Bernhard — Univ. Claude Bernard of Lyon
van der Schaft, Arjan J. — Univ. of Groningen

Port-Hamiltonian systems theory has proven to be a versatile and insightful framework for the modeling, simulation and control of general (finite- and infinite-dimensional) multi-physics systems. Its main strengths are its compositionality (power-conserving interconnections of port-Hamiltonian systems are again port-Hamiltonian), as well as the fact that the port-Hamiltonian formulation makes explicit the presence of balance equations (i.e., conservation laws with source terms) implying the preservation (or decrease) of the internal energy, contrary to other network modeling approaches. Its most important feature is to define a geometric structure (called Dirac structure) capturing the network interconnection structure. The identification of these structural properties has turned out to be of crucial importance in the development of modular dynamical models for complex multi-domain physical systems, the numerical simulation preserving the physical invariants, and in the design of control strategies, which in the nonlinear case do not always aim at compensating nonlinearities, but instead make use of beneficial nonlinearities. The aim of this mini-course is to present recent developments on the definition of Dirac structures and port-Hamiltonian systems associated with complex discrete topologies such as k-complexes (k-dimensional generalizations of graph topologies) and relate them with the port-Hamiltonian formulation of complex systems of balance equations defined on bounded spatial domains, their direct formulation on discrete spatial domains, and spatial semi-discretization using geometric structure preserving methods. The mini-course will consist of two blocks, each of 100 minutes.

10:30-10:50 TuB7.1

Introduction to Port-Hamiltonian Systems, pp. 154-157

van der Schaft, Arjan J. — Univ. of Groningen

10:50-11:20 TuB7.2

Stokes-Dirac Structures and Distributed Parameter Port-Hamiltonian Systems , pp. 154-157

van der Schaft, Arjan J. — Univ. of Groningen

11:20-11:45 TuB7.3

Boundary Port-Hamiltonian Systems in Engineering: Multiphysical and Multilevel Systems, pp. 154-157

Maschke, Bernhard — Univ. Claude Bernard of Lyon

11:45-12:10 TuB7.4

Weak Form of Stokes-Dirac Structures and Mixed Galerkin Discretization of Port-Hamiltonian Systems, pp. 154-157

Kotyczka, Paul — Tech. Univ. München

12:10-12:35 TuB7.5

Discrete Modeling and Numerical Approximation of Conservation Laws on k-Complexes, pp. 154-157

Kotyczka, Paul — Tech. Univ. München

12:35-13:00 TuB7.6

Relations with Standard Geometric Discretization Methods, pp. 154-157

Kotyczka, Paul — Tech. Univ. München

TuD1 — Room 2463

Convex Algebraic Geometry II (Invited Session)

Chair: Helton, J. William — UC San Diego
Co-Chair: Saunderson, James — Monash Univ
Organizer: Blekherman, Gregory — Georgia Inst. of Tech
Organizer: Henrion, Didier — LAAS-CNRS
Organizer: Vinnikov, Victor — Ben Gurion Univ. of the Negev

16:00-16:25 TuD1.1

Advances in Real Algebraic Geometry for Matrix Variables, Part II (I), pp. 158-158

Helton, J. William — UC San Diego
Klep, Igor — The Univ. of Auckland
Volčič, Jurij — Ben-Gurion Univ. of the Negev

The talk will be one of 3 coordinated talks (Helton, Klep, Volčič) concerning inequalities and equalities for functions having matrix variables. Matrix multiplication does not commute, so the functions we study are typically noncommutative (nc) polynomials or rational functions. Such mathematics is central to linear systems problems which are specified entirely by a signal flow diagram and L^2 performance specs on signals. The reason being: a system connection law amounts to an algebraic operation on nc quantities, while L^2 performance constraints, through use of quadratic "storage

functions", convert to matrix inequalities.

Studies of commutative polynomial inequalities are central to classical mathematics and come under the heading of Real Algebraic Geometry (RAG). Hence linear systems problems cry out for development of a noncommutative RAG. This field has developed greatly over the last decade, pushed partly by systems motivation and greatly by unfolding the parallels to classical RAG.

16:25-16:50 TuD1.2

Advances in Real Algebraic Geometry for Matrix Variables, Part I (I), pp. 159-159

Helton, J. William — UC San Diego
Klep, Igor — The Univ. of Auckland
Volčič, Jurij — Ben-Gurion Univ. of the Negev

The talk will be one of 3 coordinated talks (Helton, Klep, Volčič) concerning inequalities and equalities for functions having matrix variables. Matrix multiplication does not commute, so the functions we study are typically noncommutative (nc) polynomials or rational functions. Such mathematics is central to linear systems problems which are specified entirely by a signal flow diagram and L^2 performance specs on signals. The reason being: a system connection law amounts to an algebraic operation on nc quantities, while L^2 performance constraints, through use of quadratic "storage functions", convert to matrix inequalities.

Studies of commutative polynomial inequalities are central to classical mathematics and come under the heading of Real Algebraic Geometry (RAG). Hence linear systems problems cry out for development of a noncommutative RAG. This field has developed greatly over the last decade, pushed partly by systems motivation and greatly by unfolding the parallels to classical RAG.

16:50-17:15 TuD1.3

Condition Numbers of Stochastic Mean Payoff Games and What They Say about Nonarchimedean Semidefinite Programming (I), pp. 160-167

Allamigeon, Xavier — INRIA Saclay -- Ile-De-France and CMAP, Ec. Pol
Gaubert, Stephane — INRIA and Ec. Pol
Katz, Ricardo David — CIFASIS-CONICET
Skomra, Mateusz — Ec. Pol. and INRIA

Semidefinite programming can be considered over any real closed field, including fields of Puiseux series equipped with their nonarchimedean valuation. Nonarchimedean semidefinite programs encode parametric families of classical semidefinite programs, for sufficiently large values of the parameter. Recently, a correspondence has been established between nonarchimedean semidefinite programs and stochastic mean payoff games with perfect information. This correspondence relies on tropical geometry. It allows one to solve generic nonarchimedean semidefinite feasibility problems, of large scale, by means of stochastic game algorithms. In this paper, we show that the mean payoff of these games can be interpreted as a condition number for the corresponding nonarchimedean feasibility problems. This number measures how close a feasible instance is from being infeasible, and vice versa. We show that it coincides with the maximal radius of a ball in Hilbert's projective metric, that is included in the feasible set. The geometric interpretation of the condition number relies in particular on a duality theorem for tropical semidefinite feasibility programs. Then, we bound the complexity of the feasibility problem in terms of the condition number. We finally give explicit bounds for this condition number, in terms of the characteristics of the stochastic game. As a consequence, we show that the simplest algorithm to decide whether a stochastic mean payoff game is winning, namely value iteration, has a pseudopolynomial complexity when the number of random positions is fixed.

17:15-17:40 TuD1.4

Certificates of Polynomial Nonnegativity Via Hyperbolic Optimization (I), pp. 168-171

Saunderson, James — Monash Univ

We present a new approach to certifying the nonnegativity of homogeneous multivariate polynomials that is based on the theory of hyperbolic polynomials. Moreover, the search for certificates of nonnegativity can be automated by solving a hyperbolic optimization problem. The main technical fact that enables these nonnegativity certificates is a polynomial parameterization (up to closure) of the dual cone of a hyperbolicity cone, a construction essentially due to Kummer, Plaumann, and Vinzant. This extended abstract presents the basic idea of such hyperbolic certificates of nonnegativity, and discusses what is known about the relationship between sums of squares and polynomials with hyperbolic certificates of nonnegativity.

TuD2 Room 2464

Efficiency and Security on Estimation and Control in Networks (Invited Session)

Chair: YANG, Chao — East China Univ. of Science and Tech
Co-Chair: Yang, Wen — East China Univ. of Science and Tech
Organizer: YANG, Chao — East China Univ. of Science and Tech
Organizer: Yang, Wen — East China Univ. of Science and Tech

16:00-16:25 TuD2.1

Event-Triggered Risk-Sensitive Maximum a Posterior Estimation for Hidden Markov Models (I), pp. 172-174

Xu, Jiapeng — The Key Lab. of Advanced Control and Optimization for Chem
Tang, Yang — East China Univ. of Science and Tech

In this work, we consider an event-triggered risksensitive state estimation problem for hidden Markov models. The event-triggered condition considered is general, which involves the current measurement and past information. We use the reference probability measure approach in solving this problem. We derive the linear recursion in the unnormalized information state conditioned on the available information of the estimator, based on which risk-sensitive maximum a posterior estimates can be evaluated. The results are extended to the vector measurement scenario as well via a sequential event-triggered approach.

16:25-16:50 TuD2.2

A Modified Iterative Ranking Method Based on Trust Network (I), pp. 175-176

Liang, Bo — Shanghai Jiao Tong Univ
Wang, Lin — Shanghai Jiao Tong Univ
Wang, Xiaofan — Shanghai Jiao Tong Univ
Yang, Wen — East China Univ. of Science and Tech

How to evaluate the intrinsic quality of products and the user reputation becomes a significant yet difficult problem. In this paper, considering the trust relationship between users, we improve the traditional iterative ranking methods by combining the traditional iterative methods with the TrustRank method. The user's reputation depends on the user's rating behavior and the TrustRank value. Our simulations demonstrate that the modified methods posses a better robustness and performance than the existing methods.

16:50-17:15 TuD2.3

Semi-Global Containment Control of Discrete-Time Linear Systems with Actuator Position and Rate Saturation (I), pp. 177-178

Zhao, Zhiyun — East China Univ. of Science and Tech
Yang, Wen — East China Univ. of Science and

Tech

Shi, Hongbo — Key Lab. of Advanced Control and Optimization for Chemical

This paper studies semi-global containment control problem for a multi-agent system. The dynamics of each follower agent in the system is described by a discrete-time linear system in the presence of actuator position and rate saturation. For each follower agent we construct a linear state feedback control law by using low gain approach such that, the states of follower agents will converge to the convex hull formed by the leader agents asymptotically when the communication topology among follower agents is a connected undirected graph and each leader agent is a neighbor of at least one follower agent.

17:15-17:40 TuD2.4

Consensus-Based Distributed Estimation under Linear Attacks (I), pp. 179-180

Xia, Yuanyuan — East China Univ. of Science and Tech

Yang, Wen — East China Univ. of Science and Tech

YANG, Chao — East China Univ. of Science and Tech

In this paper, we consider a consensus-based distributed filtering over wireless sensor networks under linear attacks. Suppose that in the network a malicious attacker injects false data into the data. First, we design an optimal estimator by minimizing the covariance of state estimation error. Then, we propose an effective detector for each sensor to resist the malicious data transmitted between the sensors in the network. Finally, the performances of the proposed estimator with the detector is demonstrated by comparing with the other typical attacking strategies.

17:40-18:05 TuD2.5

Communication-Saving Design by Stochastic Event Triggers (I), pp. 181-184

YANG, Chao — East China Univ. of Science and Tech

Yang, Wen — East China Univ. of Science and Tech

Shi, Hongbo — Key Lab. of Advanced Control and Optimization for Chemical

This paper proposes a design framework of sensor communication by using the stochastic event triggers, which aims at best saving the communication resources. The system to be considered is as follows: a sensor takes measurements of the states of a dynamic process and sends the information to a remote estimator, and the estimator computes the state estimates for the dynamic process. To save communication resources, a set of stochastic event triggers on the measurements are assigned to the sensor. At each sampled time, when no trigger is triggered, the sensor sends nothing to the estimator; when one of them is triggered, the sensor sends the identity code of the corresponding trigger. It is shown that once the estimator receives the identity of the trigger, it is equivalent for the estimator to receiving a measurement from a virtual sensor. Based on it, the system performance under the proposed communication is analyzed, and the design of specific models is considered.

TuD3 Room 2465

Distributed Parameter Systems III (Invited Session)

Chair: Morris, Kirsten A. — Univ. of Waterloo

Co-Chair: Wang, Jun-Min — Beijing Inst. of Tech

Organizer: Jacob, Birgit — Bergische Univ. Wuppertal

Organizer: Demetriou, Michael A. — Worcester Pol. Inst

Organizer: Morris, Kirsten A. — Univ. of Waterloo

16:00-16:25 TuD3.1

Localized Stability Analysis and Design of Symmetric Spatially Distributed Systems Over Sparse Proximity Graphs (I), pp. 185-188

Motee, Nader — Lehigh Univ

Sun, Qiyu — Univ. of Central Florida

The focus of this paper is on the finite or infinite dimensional class of spatially distributed linear systems with Hermitian and sparse state matrices. We show that exponential stability of this class of systems can be inferred in a decentralized and spatially localized manner, which is practically relevant to many real-world applications (e.g., systems with spatially discredited PDE models). Then, we obtain several sufficient conditions that allow us to adjust strength of existing couplings in a network in order to sparsify or grow a network, while ensuring global stability. Our proposed necessary and sufficient stability certificates are independent of the dimension of the entire system. Moreover, they only require localized knowledge about the state matrix of the system, which makes these verifiable conditions desirable for design of robust spatially distributed linear systems against subsystem failure and replacement.

16:25-16:50 TuD3.2

Stability of a Hyperbolic System of the Interconnected Schr"{o}dinger and Wave Equations (I), pp. 189-196

Wang, Jun-Min — Beijing Inst. of Tech

Wang, Fei — Beijing Inst. of Tech

Liu, Xiangdong — Beijing Inst. of Tech

In this paper, we consider the stability of a hyperbolic system of the interconnected Schr"{o}dinger and wave equations, where the only distributed dissipative control is forced at the wave equation and there is no any control fixed at the Schr"{o}dinger. The Schr"{o}dinger can be exponentially stabilized by the inter-change transmission between the Schr"{o}dinger and wave at the interconnection boundary. We show that the whole system is well-posed and exponentially stable in the energy Hilbert space. A numerical computation is presented for the distributions of the spectrum of the whole system, and it is found that the spectrum of the Schr"{o}dinger depends largely on the interconnected transmission parameter and the decay of the wave equation.

16:50-17:15 TuD3.3

On LQG Control of Stochastic Port-Hamiltonian Systems on Infinite-Dimensional Spaces (I), pp. 197-203

Lamoline, Francois — Univ. De Namur

Winkin, Joseph J. — Univ. of Namur

This paper presents an ongoing research on the infinite horizon Linear Quadratic Gaussian (LQG for short) control problem for stochastic port-Hamiltonian systems on infinite-dimensional spaces with bounded input, output and noise operators. An adapted version of the separation principle is stated for this specific class of systems. Under suitable conditions, the LQG controller is shown to preserve the stochastic port-Hamiltonian structure. Finally, we propose some perspectives and open tracks to follow. The theory is illustrated on an example of vibrating string subject to a Hilbert space valued random forcing.

17:15-17:40 TuD3.4

Open Physical Systems: From GENERIC to Port-Hamiltonian Systems (I), pp. 204-211

Moses Badlyan, Arbi — Tech. Univ. Berlin

Maschke, Bernhard — Univ. Claude Bernard of Lyon

Beattie, Christopher A. — Virginia Tech

Mehrmann, Volker — TU Berlin

Formulations of open physical systems within the framework of Non-Equilibrium Reversible/Irreversible Coupling (associated with the acronym “GENERIC") is related in this work with state-space realizations that are given as boundary port-Hamiltonian systems.

This reformulation is carried out explicitly by splitting the dynamics of the system into a reversible contribution given by a Poisson bracket and an irreversible contribution given by a symmetric dissipation bracket, and is facilitated by the introduction of an exergy-like potential.

17:40-18:05 TuD3.5

Concurrent Optimal Control and Actuator Design for Semi-Linear Systems (I), pp. 212-215

Edalatzadeh, M. Sajjad — Univ. of Waterloo

Morris, Kirsten A. — Univ. of Waterloo

Semi-linear partial differential equations model a wide spectrum of physical systems with distributed parameters. It is shown that under sufficient conditions on nonlinearities in the systems and in cost functions, an optimal control input and optimal actuator design exist. First-order optimality conditions are obtained that characterize the optimizer. The results are used to address vibration suppression in a nonlinear railway track.

TuD4 Room 2502

Majorization Theory and Its Applications (Invited Session)

Chair: Chen, Wei — The Hong Kong Uni. of Sci. and Tech

Co-Chair: Jiang, Yi — Fudan Univ

Organizer: MO, Yanfang — The Hong Kong Univ. of Science and Tech

Organizer: Chen, Wei — The Hong Kong Uni. of Sci. and Tech

Organizer: Qiu, Li — Hong Kong Univ. of Sci. & Tech

16:00-16:25 TuD4.1

Decision Feedback Based Transceiver Optimization for MIMO Inter-Symbol Interference Channels (I), pp. 216-221

Jiang, Yi — Fudan Univ

This paper deals with optimizing a transceiver, which consists of a linear time invariant (LTI) matrix filter at the transmitter and a generalized (nonlinear) decision feedback (DF) receiver, for {em single-carrier} data transmission over multi-input multi-output (MIMO) inter-symbol interference (ISI) channels. Considering a spatial multiplexing approach for which multiple scalar substreams are transmitted simultaneously, we adopt some cost function $f_0({{rm MSE}_i})$ to measure the overall system performance, where ${rm MSE}_i$'s are the mean-squared errors (MSE) of the unquantized estimates at the receiver. Based on majorization theory and the generalized triangular decomposition (GTD), we derive the optimum DF based transceiver which minimizes $f_0({{rm MSE}_i})$ subject to the total input power constraint. It is proven that for {em any} cost function f_0 the optimum transmitter is of the same special structure and hence the original complicated matrix optimization problem can be significantly simplified to a problem with scalar variables. Furthermore, if the cost function is specialized to the cases where the composite function $f_0 circ exp$ is Schur-convex, then the optimum nonlinear transceiver turns out to be a generalization of the uniform channel decomposition (UCD) scheme; when $f_0 circ exp$ is Schur-concave, the optimum nonlinear design degenerates to diagonal transmission, which converts a MIMO ISI channel into multiple decoupled SISO ISI channels.

16:25-16:50 TuD4.2

Staircase Pattern Constrained Zero-One Matrix Completion with Uncertainties and Its Applications (I), pp. 222-225

MO, Yanfang — The Hong Kong Univ. of Science and Tech

Chen, Wei — The Hong Kong Uni. of Sci. and Tech

Qiu, Li — Hong Kong Univ. of Sci. & Tech

In this paper, we analyze the existence conditions of a special class of constrained zero-one matrices with uncertainties. Classically, it asks how to characterize a class of zero-one matrices with given row sum and column sum vectors. The solution is given by a concise majorization inequality, widely known as the Gale-Ryser theorem. The authors further explore it in a more complicated case. Firstly, some fixed zeros or ones are given in a prescribed staircase pattern of positions. Secondly, each row or column sum is not exactly given but described by a boundary interval. It shows that such a constrained zero-one matrix exists if and only if two structure tensors are jointly nonnegative, which is consistent with the previous majorization condition.

16:50-17:15 TuD4.3

Majorization Theory in Sensor Scheduling (I), pp. 226-229

YANG, Chao — East China Univ. of Science and Tech

Yang, Wen — East China Univ. of Science and Tech

Shi, Ling — Hong Kong Univ. of Sci. and Tech

This paper presents that the majorization theory plays an essential role in a class of sensor scheduling problems, whose solutions all have periodic or uniformly distributed patterns. This paper revisits the problem of communication time scheduling for a single sensor with local computation capability, and strengthens its original result by the majorization theory. The scheduling for a single normal sensor in a general-order system is also studied, and the optimal schedules for minimizing the upper bound of objective function is provided.

17:15-17:40 TuD4.4

Results on Transmission Power Control for Remote State Estimation (I), pp. 230-232

Wu, Junfeng — Zhejiang Univ

Li, Yuzhe — HKUST

Quevedo, Daniel — Paderborn Univ

Shi, Ling — Hong Kong Univ. of Sci. and Tech

We consider a sensor transmission power control problem for remote state estimation. In this problem, a sensor sends its local estimate to a remote estimator over a wireless packet-dropping communication channel. The transmission power is determined by a recently proposed algorithm which uses the innovative information contained in the measurement. In the current paper, we focus on parameter optimization arising from the selection of design parameters for this power controller. The existing work obtained a suboptimal solution to the parameter optimization problem, while by using a vector rearrangement inequality argument and the vector majorization, we now show that there exists an optimal solution within a subset of the whole feasible set. By leveraging this property, we obtain an optimal solution via solving a convex optimization problem.

17:40-18:05 TuD4.5

Stability of General Dynamical Networks Via Majorization of Phases (I), pp. 233-235

Wang, Dan — HKUST

Chen, Wei — The Hong Kong Uni. of Sci. and Tech

Khong, Sei Zhen — Univ. of Minnesota

Qiu, Li — Hong Kong Univ. of Sci. & Tech

In this paper, we study the stability of a linear time-invariant dynamical network with both node and edge dynamics. It is demonstrated that at each frequency, the phases of the eigenvalues of the loop-gain transfer function are bounded from above (below, respectively) by the sum of the maximal (minimal, respectively) phases of the node and edge dynamics. Based on this property and the generalized Nyquist stability criterion, a sufficient condition for closed-loop stability is derived in terms of the phases of node and edge dynamics. This serves as an interesting starting point in developing a more general “small phase theorem”.

TuD5 Room 2503

Secure and Efficient Information Processing in Cyber-Physical Systems (Invited Session)

Chair: Liu, Qipeng — Nanyang Tech. Univ
Organizer: Ren, Xiaoqiang — KTH
Organizer: Li, Yuzhe — HKUST

16:00-16:25 TuD5.1

Asymptotic and Finite-Time Almost Global Attitude Tracking: Representations Free Approach (I), pp. 236-239

Wei, Jieqiang — KTH Royal Inst. of Tech
Wu, Junfeng — KTH
Sandberg, Henrik — KTH Royal Inst. of Tech
Johansson, Karl Henrik — Royal Inst. of Tech

In this paper, the attitude tracking problem is considered using the rotation matrices. Due to the inherent topological restriction, it is impossible to achieve global stability with any continuous attitude control system on SO(3). Hence in this work, we propose some control protocols that achieve almost global tracking asymptotically and in finite time, respectively. In these protocols, no world frame is needed and only relative state information are requested. For the closed-loop systems, Filippov solutions and non-smooth analysis techniques are adopted to handle the discontinuities.

16:25-16:50 TuD5.2

A Clustering-Based Approach for Secure State Estimation (I), pp. 240-242

Guo, Ziyang — Hong Kong Univ. of Science and Tech
Shi, Dawei — Harvard Univ
Quevedo, Daniel — Paderborn Univ
Shi, Ling — Hong Kong Univ. of Sci. and Tech

We consider the problem of estimating the state of a linear time-invariant Gaussian system using N sensors, where a subset of the sensors can potentially be compromised by an adversary. In this case, localizing the compromised sensors is of crucial importance for obtaining an accurate state estimate. Inspired by the clustering algorithm in machine learning, we propose a Gaussian-mixture-model-based detection mechanism. It clusters the local state estimates autonomously and provides beliefs for the sensors, based on which measurements can be fused accordingly. When a subset of the sensors are under attack, we analyze the remote estimation error covariance for the proposed clustering-based detection algorithm and evaluate the performance of the proposed algorithm through the average belief. Moreover, the effectiveness of the proposed algorithm is verified under different attack scenarios through simulation examples.

16:50-17:15 TuD5.3

Kalman Filtering with Intermittent Observations: A Structural Approach (I), pp. 243-246

Liu, Qipeng — Nanyang Tech. Univ
Mo, Yilin — Nanyang Tech. Univ

In this extended abstract, we revisit the problem of Kalman filtering with intermittent observations. It is known that the definition of non-degeneracy plays a key role in determining the critical value of packet arrival probability for bounded estimate errors. In this extended abstract, we provide topological conditions for the existence of eigen-cycle, which can lead to degenerate systems. We prove that aperiodicity of the graph corresponding to the *A* matrix is a necessary condition for non-existence of eigen-cycle. We also prove that a special class of aperiodic graphs does not contain non-zero eigen-cycles.

17:15-17:40 TuD5.4

Time-Dependent Metric Graph: Wave Dynamics,

Popov, Igor — ITMO Univ
Nikiforov, Dmitri — ITMO Univ

We consider a metric graph under the assumption that lengths of its edges vary in time. The dynamics of waves of different nature on the graph is compared.We investigate classical waves governed by wave equation, non-relativistic quantum Schr¨odinger) particles and relativistic (Dirac) particles. Star like graph and graph with a loop are considered.

17:40-18:05 TuD5.5

Scattering of Elastic Waves by Point-Like Obstacle in Two-Dimensional Case

Blinova, Irina — ITMO Univ
Boitsev, Anton — ITMO Univ
Froehly, Andre — Leibniz Univ. Hannover
Neidhardt, Hagen — ITMO Univ
Popov, Igor — ITMO Univ

A model of scattering of elastic wave by point-like scatterer on the plane is suggested. Point-like perturbation is constructed for the Lam´e operator in the framework of the theory of self-adjoint extensions of symmetric operators. The eigenvalues of the model operator are found. The scattering matrix is obtained.

TuD6 Room 2504

Algebraic Systems Theory (Regular Session)

Chair: Zerz, Eva — RWTH Aachen Univ
Co-Chair: Kolar, Bernd — Johannes Kepler Univ. Linz

16:00-16:25 TuD6.1

Application of Symmetry Groups to the Observability Analysis of Partial Differential Equations, pp. 247-254

Kolar, Bernd — Johannes Kepler Univ. Linz
Rams, Hubert — JKU Linz
Schöberl, Markus — Johannes Kepler Univ. Linz

Symmetry groups of PDEs allow to transform solutions continuously into other solutions. In this paper, we use this property for the observability analysis of nonlinear PDEs with input and output. Based on a differential-geometric representation of the nonlinear system, we derive conditions for the existence of special symmetry groups that do not change the trajectories of the input and the output. If such a symmetry group exists, every solution can be transformed into other solutions with the same input and output trajectories but different initial conditions, and this property can be used to prove that the system is not observable. We also put emphasis on showing how the approach simplifies for linear systems, and how it is related to the well-known observability concepts from infinite-dimensional linear systems theory.

16:25-16:50 TuD6.2

Controlled Invariance for 1D and 2D Time-Varying Nonlinear Control Systems, pp. 255-258

Yuno, Tsuyoshi — Kyushu Univ
Zerz, Eva — RWTH Aachen Univ

We study invariance properties with polynomially nonlinear and time-varying ODE systems (also termed one-dimensional or 1D systems due to the presence of one independent variable). The results are used to characterize time-varying controlled invariant varieties, that is, varieties that can be rendered invariant by state feedback. Analogous questions are also considered for a class of PDE systems in two independent variables (so-called two-dimensional or 2D systems), namely those which can be described by continuous Roesser models.

16:50-17:15 TuD6.3

Roots of Polynomials with Positive Coefficients, pp. 259-265

Verriest, Erik I. — Georgia Inst. of Tech

Hyun, Nak-seung Patrick — Georgia Inst. of Tech

A necessary condition for stability of a finite-dimensional linear time-invariant system is that all the coefficients of the characteristic equation are strictly positive. However, it is well-known that this condition is not sufficient, except for n less than 3. In this paper, we show that any polynomial that has positive coefficients cannot have roots on the negative real axis. Conversely, if a polynomial has no roots on the positive real axis, a polynomial with positive coefficients can be found so that the product of the two polynomials also has positive coefficients. A simple upper bound for the degree of this multiplier polynomial is given. One application of the main result is that under a strict condition, it is possible to find a non-minimal realization of a given transfer function using only positive multipliers (except for the "minus" in the standard feedback comparator).

17:15-17:40 TuD6.4

On Stabilizability of Strict Additive Convex Processes with Arbitrary Stability Domains, pp. 266-269

Oner, Isil — Gebze Tech. Univ
Camlibel, Kanat — Univ. of Groningen

This paper studies stabilizability problem with respect to an arbitrary stability domain for strict closed additive convex processes. The main results state necessary and sufficient conditions in terms of the eigenstructure of the dual process. The results presented in this paper are stronger than those of existing in the literature in two respects: (i) they are valid for arbitrary stability domains and (ii) they guarantee existence of Bohl-type stable trajectories. We also demonstrate the application of the main results by streamlining them for linear systems subject to conic input constraints.

17:40-18:05 TuD6.5

Feedback Stabilization of Switched Differential Algebraic Systems, pp. 270-275

Mojica-Nava, Eduardo — Univ. Nacional De Colombia
Rakoto-Ravalontsalama, Naly — IMT Atlantique and LS2N Lab

A stabilization problem for a switched differential-algebraic system is investigated. We propose an approach for solving effectively the stabilization problem for an autonomous linear switched differential-algebraic system based on projector and flow matrices. In switched DAEs, the switches can induce jumps in certain state-variables, and it has been shown that the formulation as a switched DAE already implicitly defines these jumps, no additional jump map must be given. These jumps can be calculated in terms of the consistency projectors. The essence of this method is to design a stabilizing controller for switched differential-algebraic systems, i.e., the continuous dynamics of each subsystem are described by sets of differential-algebraic equations, using an averaging switched DAE model based on consistency projector and flow matrices to guarantee convergence towards an equilibrium point via fast switching.

TuD7 — Room 5506

Delay and Event Systems (Regular Session)

Chair: Peet, Matthew Monnig — Arizona State Univ
Co-Chair: Rakoto-Ravalontsalama, Naly — IMT Atlantique and LS2N Lab

16:00-16:25 TuD7.1

Synthesis of Full-State Observers for Time-Delay Systems Using SOS, pp. 276-283

Peet, Matthew Monnig — Arizona State Univ
Gu, Keqin — Southern Illinois Univ. at Edwardsville

In this paper, we develop an SOS approach for design of observers for time-delay systems. The method is an extension of recently developed algorithms for control of infinite-dimensional systems. The observers we design are more general than the class of observers most commonly associated with time-delay systems in that they directly correct both the estimate of present state as well as the history of the state. The result is that the observer is itself a PDE. In this case the traditional notions of strong and weak observability do not apply and the resulting observer-based controllers can significantly outperform existing approaches.

16:25-16:50 TuD7.2

On Switchable Languages of Discrete-Event Systems with Weighted Automata, pp. 284-289

Canu, Michael — Univ. De Los Andes, Bogota
Rakoto-Ravalontsalama, Naly — IMT Atlantique and LS2N Lab

The notion of switchable languages has been defined by Kumar, Takai, Fabian and Ushio in [Kumar-et-al.05]. It deals with switching supervisory control, where switching means switching between two specifications. In this paper, we first extend the notion of switchable languages to n languages, (n greater than 3). Then we consider a discrete-event system modeled with weighted automata. The use of weighted automata is justified by the fact that it allows us to synthesize a switching supervisory controller based on the cost associated to each event, like energy for example. Finally the proposed methodology is applied to a simple example.

16:50-17:15 TuD7.3

Insights in Characterizing Asymptotic Behavior for Quasipolynomials with Two Delays, pp. 290-297

Martínez-González, Alejandro — Univ. Autónoma De San Luis Potosí
Méndez-Barrios, César Fernando — Univ. Autónoma De San Luis Potosí
Niculescu, Silviu-Iulian — Umr Cnrs 8506, Cnrs-Supelec
Chen, Jie — City Univ. of Hong Kong
Romero, Jose-Guadalupe — ITAM

This paper proposes an analytic method to characterize the behavior of multiple critical roots of a retarded system with two delays. Expressing locally the related characteristic function, as a Weierstrass polynomial, we derive several results to analyze the stability behavior of such characteristic roots with respect to small variations on the delay parameters. The proposed results are illustrated by considering several numerical examples.

17:15-17:40 TuD7.4

Stability of Constant Gain Output Feedback for Two-Input Systems with Asynchronous Sample and Update Timing, pp. 298-301

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

In this extended abstract, a stability certificate is presented for sampled-data implementations of static output feedback control with asynchronous sensor sampling and zero-order-hold actuator updates, given continuous-time two-input-single-output linear time-invariant system dynamics. The approach involves structured integral quadratic constraint (IQC) based robustness analysis, given individual bounds on the uncertain sample and two update intervals involved, and relationships between these. New IQCs for an operator that depends on multiple time-varying delays are also presented.

17:40-18:05 TuD7.5

Input-Output Decoupling and Linearization of Nonlinear Two-Input Two-Output Time-Varying Delay Systems, pp. 302-308

Nicolau, Florentina — ENSEA
Haidar, Ihab — Supélec-CNRS-Univ. Paris Sud
Barbot, Jean Pierre — ENSEA
Aggoune, Woihida — ENSEA

In this paper, we study the input-output decoupling and linearization of nonlinear two-input two-output time-varying delay systems. When

working with delay systems, two problems may arise when constructing an invertible feedback transformation for which the input-output map of the feedback modified systems is linear. The first issue is the boundedness of the control and the second one is its causality. We develop an algorithm allowing the construction of a causal and bounded feedback which permits to solve the input-output decoupling and linearization problem. The idea of our algorithm is to introduce, at each step, when the input-output decoupling is not possible, an artificial delay for the input that appears "too early" in the system. To that end, we propose at each step a precise procedure for defining a simple feedback transformation.

Technical Program for Wednesday July 18, 2018

WeTr	LTB
Tribute to Bruce A. Francis	Plenary Session
Chair: Qiu, Li	Hong Kong Univ. of Sci. & Tech

11:45-12:30	WeTr
Title TBD	
Helton, J. William	UC San Diego
Bruce Francis and his contributions to sampled-data control and signal processing	
Yamamoto, Yutaka	Kyoto Univ.
The robot rendezvous problem	
Lin, Zhiyun	Hangzhou Dianzi University

ThB1 Room 2463

Coding Theory: Codes and Security (Invited Session)

Chair: Han, Guangyue	The Univ. of Hong Kong
Co-Chair: Roca, Alicia	Univ. Pol. De València
Organizer: Han, Guangyue	The Univ. of Hong Kong
Organizer: Pinto, Raquel	Univ. of Aveiro
Organizer: Rosenthal, Joachim	Univ. of Zurich

10:30-10:55 ThB1.1

Weight Two Masking of the Reed-Solomon Structure in Conjunction with List Decoding (I), pp. 309-314

Khathuria, Karan	Univ. of Zurich
Rosenthal, Joachim	Univ. of Zurich
Weger, Violetta	Univ. of Zurich

We present a code-based cryptosystem, in which we use Reed-Solomon codes as secret codes and a weight two matrix for masking, to make the system secure against attacks based on the Schur product. We combine this with the Guruswami-Sudan list decoding for decryption to get lower key sizes. As a consequence, we obtain a key size reduction of 21.8% compared to the standard McEliece cryptosystem proposed by Bernstein et al.

10:55-11:20 ThB1.2

Decryption Failures As Side Channel Attacks (I), pp. 315-318

Hall, Joanne	RMIT Univ
Kuijper, Margreta	Univ. of Melbourne

Securing information involves multiple layers: mathematical encryption, protocol design, software implementation and hardware implementation. Multiple disciplines are involved, mathematicians, software developers, telecommunication technicians and cybersecurity engineers.

Mathematical cryptanalysis analyses encrypted information, whereas side channel cryptanalysis analyses information leaked via software/hardware implementation. In this presentation we give an overview of reaction attacks due to protocol-based leaked information. We particularly look at McEliece Cryptosystems, also called Code Based Cryptography, using LDPC codes. The LDPC McEliece crypto system is vulnerable to reaction attacks.

We discuss reaction attacks that use decryption failure events to gather information about the decryption key. We propose to consider such decryption failures as a side channel from which information can be gathered. We conclude that any code-based cryptographic protocol requires careful cybersecurity engineering management of decryption failure events.

11:20-11:45 ThB1.3

Extensions of the Berlekamp-Massey Algorithm (I), pp. 319-322

Roca, Alicia	Univ. Pol. De València
Baragaña, Itziar	Univ. Del País Vasco

Given a finite sequence of scalars, the Berlekamp-Massey algorithm solves the problem of finding a linear feedback shift register of minimal length which generates it. When instead of a sequence of scalars, we are given a sequence of matrices, it can be interpreted as the problem of finding a minimal partial realization and also as the problem of finding a minimal length right (left) matrix generator of the sequence. We generalize the main result standing the Berlekamp-Massey algorithm in terms of the partial Brunovsky indices of a finite sequence of matrices and design a strategy to obtain them. Once they are known, we can compute a minimal partial realization and a minimal length right (left) matrix generator of the sequence.

11:45-12:10 ThB1.4

A McEliece-Type Cryptosystem Based on Convolutional Codes (I), pp. 323-326

Almeida, Paulo	Univ. De Aveiro
Napp, Diego	Univ. of Aveiro

In this paper we present a new variant of the McEliece cryptosystem. In contrast to the typical approach, where block codes are used, we propose the use of a convolutional encoder to be part of the public key. In this setting the message is a sequence of messages instead of a single block message and the errors are added randomly throughout the sequence. We point out several advantages of such an approach and indicate interesting lines for future research.

ThB2 Room 2464

Positivity, Factorizations, and State Space Realizations for Scalar and Matrix Variables I (Invited Session)

Chair: Vinnikov, Victor	Ben Gurion Univ. of the Negev
Co-Chair: Infusino, Maria	Univ. of Konstanz
Organizer: Ball, Joseph A.	Virginia Tech
Organizer: Helton, J. William	UC San Diego
Organizer: Klep, Igor	The Univ. of Auckland
Organizer: Vinnikov, Victor	Ben Gurion Univ. of the Negev

10:30-10:55 ThB2.1

Monotone Maps for Manipulating Matrix Inequalities (I), pp. 327-330

Pascoe, James Eldred	Washington Univ. in St. Louis

A natural partial ordering on self-adjoint matrices is to set A <= B whenever B - A is positive semidefinite. We say a function f:(a,b) -> R is matrix monotone in the sense that A <= B$ implies f(A) <= f(B), where f is evaluated using the functional calculus. (If the function f were a rational function, f(A) is simply defined by substituting A into f.) In 1934, Charles Loewner showed that a function is matrix monotone if and only if it is analytic and analytically continues to the upper half plane in C as a map into the closed upper half plane. With Ryan Tully-Doyle, we characterized the appropriate generalization for systems of matrix inequalities by proving a non-commutative version of Loewner's theorem. Our work unites some of the basic theory already encountered in the wild in the study of matrix means, the Schur complement, random matrix theory, complete positivity, free probability and free analysis. In this talk, we will give the classical theory and some of its applications, then proceed to describe the notion of non-commutative function theory, and finally describe my current work on the non-commutative Loewner theorem with a several examples and applications.

10:55-11:20 ThB2.2

Antidifferentiation of Noncommutative Functions (I), pp. 331-334

Stevenson, Leonard	Drexel Univ
Kaliuzhnyi-Verbovetskyi, Dmitry	Drexel Univ
Vinnikov, Victor	Ben Gurion Univ. of the Negev

In "Foundations of Free Noncommutative Function Theory" Verbotvetskyi and Vinnikov introduce an algebraic construction that is used to develop a generalized derivative operator, called the difference-differential operator, for free noncommutative functions. This paper will construct an inverse to the difference-differential operator and determine what conditions must be imposed on an nc function to allow it to have an antiderivative.

11:20-11:45 ThB2.3

Stable Polynomials in Matrix Variables, Their Properties and

Representations (I), pp. 335-335

Volčič, Jurij — Ben-Gurion Univ. of the Negev

A multivariate polynomial is stable if it has no zeros in the positive orthant of the C^n. Stable polynomials are a classical topic in control theory and in areas of mathematics ranging from complex analysis to real algebraic geometry. The talk describes a new class of results for noncommutative polynomials that attain only nonsingular values in the matricial positive orthant.

In recent years, there has been an increased interest in multivariate stable polynomials and closely related families (e.g. hyperbolic polynomials or rational inner functions). One of the most prominent new problems is the existence of distinguished determinantal representations for stable polynomials, which is related to the generalized Lax conjecture, the multivariate Pólya-Schur program, and the celebrated Kadison-Singer problem. Such a determinantal representation is a structural feature that naturally extends from scalar variables to matrix variables, which leads to questions about stable linear matrix pencils, and stable noncommutative polynomials and rational functions. The talk will address this noncommutative aspect of stability inspired by free analysis and free real algebraic geometry.

11:45-12:10 ThB2.4

Beurling-Lax Representations for Weighted Bergman Shift-Invariant Subspaces: The Free Noncommutative Setting (I), pp. 336-339

Ball, Joseph A. — Virginia Tech

The Beurling-Lax-Halmos theorem tells us that any invariant subspace ${mathcal M}$ for the shift operator $S colon f(z) mapsto z f(z)$ on the vectorial Hardy space over the unit disk $H^{2}_{mathcal Y} = {f(z) = sum_{j=0}^{infty} f_{j} z^{j} colon | f |^{2} =sum_{j ge 0} | f_{j} |^{2} < infty}$ (the Reproducing Kernel Hilbert Space with reproducing kernel $K(z,w) = (1 - z overline{w})^{-1} I_{mathcal Y}$) can be represented as ${mathcal M} = M_{Theta} H^{2}_{mathcal U}$ where $M_{Theta} colon H^{2}_{mathcal U} to H^{2}_{mathcal Y}$ is an isometric multiplication operator $M_{Theta} colon u(z) mapsto Theta(z) u(z)$. One proof constructs $Theta$ as the transfer-function of a discrete-time input-state-output linear system explicitly constructed from the shift-invariant subspace cM. We discuss analogues of this result and related constructions for the setting of multivariable weighted Bergman spaces in the free noncommutative setting.

12:10-12:35 ThB2.5

The Realizability Problem for Point Processes: An Explicit Construction on the D-Dimensional Lattice (I), pp. 340-341

Infusino, Maria — Univ. of Konstanz

In this talk we focus on a particular instance of the realizability problem, namely, on the question of establishing whether two given functions non-negative and symmetric on the d-dimensional lattice (d positive integer) are the first two correlation functions of a translation invariant point process on on the d-dimensional lattice. We present a joint work with Emanuele Caglioti and Tobias Kuna, where we provide an explicit construction of such a process for any d>=2 under some natural assumptions relevant for applications in fluid theory and material science (iso-g processes).

ThB3 — Room 2465

Optimal Control and Hamilton-Jacobi-Bellman Equations (Invited Session)

Chair: Dower, Peter M. — Univ. of Melbourne
Co-Chair: McEneaney, William — Univ. of California, San Diego
Organizer: Dower, Peter M. — Univ. of Melbourne
Organizer: McEneaney, William — Univ. of California, San Diego

10:30-10:55 ThB3.1

A Characteristics Based Curse-Of-Dimensionality-Free Approach for Approximating Control Lyapunov Functions and Feedback Stabilization (I), pp. 342-349

Yegorov (Egorov), Ivan — Univ. of Melbourne
Dower, Peter M. — Univ. of Melbourne
Gruene, Lars — Univ. of Bayreuth

This paper develops a curse-of-dimensionality-free numerical approach to construct control Lyapunov functions (CLFs) and stabilizing feedback strategies for deterministic control systems described by systems of ODEs. An extension of the Zubov method is used to represent a CLF as the value function for an appropriate infinite-horizon optimal control problem. The infinite-horizon stabilization problem is approximated by an exit time problem, with target set given by a sufficiently small closed neighborhood of the origin in the state space. In order to compute the related value function and optimal feedback control law separately at different initial states and thereby to attenuate the curse of dimensionality, an extension of a recently developed characteristics based framework is proposed. Theoretical foundations of the developed approach are given together with practical discussions regarding its implementation, and numerical examples are also provided. In particular, it is pointed out that the curse of complexity may remain a significant issue even if the curse of dimensionality is avoided.

10:55-11:20 ThB3.2

Basis Adaptation for a Max-Plus Eigenvector Method Arising in Optimal Control (I), pp. 350-355

Dower, Peter M. — Univ. of Melbourne

A standard max-plus eigenvector method arising in nonlinear optimal control is encapsulated within a basis function adaptation iteration. A level set corresponding to the target Hamiltonian back-substitution error is estimated at each step, using the value function approximation obtained by the eigenvector method. This estimate is used to construct and add new functions to the basis employed by the eigenvector method, with the objective of enlarging the target level set iteratively. The utility of the ensuing iteration is illustrated by example.

11:20-11:45 ThB3.3

Scalable Iterations for Solving Constrained LQ Control Problems with Cascade Dynamics (I), pp. 356-359

Cantoni, Michael — Univ. of Melbourne
Zafar, Armaghan — Univ. of Melbourne
Farokhi, Farhad — The Univ. of Melbourne

This paper is about the computation of constrained optimal controls for series interconnections of heterogeneous sub-systems with linear discrete-time dynamics. The optimal control problem is first formulated in a form that is amenable to iterative solution by the alternating direction method of multipliers (ADMM). It is observed that this technique yields per-iteration computational burden that scales linearly in the both the number of systems along the cascade and the length of the time-horizon. Moreover, parallelization of the computation across a network of processors is possible with an information exchange architecture that mirrors the cascade structure of the system. Recent work, which also spatial structure within the context of interior point methods for the problem, achieves per-iteration computational cost that scales linearly in the cascade length, but cubically in the time horizon. On the other hand, interior point methods will typically take significantly fewer iterations to converge than the proposed first order method. With this in mind, convergence of the latter is explored numerically as the number of sub-systems and time horizon are varied.

11:45-12:10 ThB3.4

A Convergent Hierarchy of Non-Linear Eigenproblems to Compute the Joint Spectral Radius of Nonnegative Matrices (I), pp. 360-365

Gaubert, Stephane — INRIA and Ec. Pol
Stott, Nikolas — INRIA Saclay & CMAP, Ec. Pol

We show that the joint spectral radius of a finite collection of nonnegative matrices can be bounded by the eigenvalue of a non-linear operator. This eigenvalue coincides with the ergodic constant of a risk-sensitive control problem, or of an entropy game, in which the state space consists of all switching sequences of a given length. We show that, by increasing this length, we arrive at a convergent approximation scheme to compute the joint spectral radius. The complexity of this method is exponential in the length of the switching sequences, but it is quite insensitive to the size of the matrices, allowing us to solve very large scale instances (several matrices in dimensions of order 1000 within a minute). An idea of this method is to replace a hierarchy of optimization problems, introduced by Ahmadi, Jungers, Parrilo and Roozbehani, by a hierarchy of nonlinear eigenproblems. We solve the latter problems by a power type iteration, avoiding the recourse to linear or semidefinite programming techniques, which allows for scalability. This is also related to maxplus-type curse of dimensionality attenuation schemes in dynamic programming.

12:10-12:35 ThB3.5

Constraints on Non-Uniqueness in Two-Point Boundary Value Problems of Conservative Dynamical Systems (I), pp. 366-371

McEneaney, William — Univ. of California, San Diego

Stationary-action problems for finite-dimensional conservative systems are considered. On sufficiently short time intervals, stationary-action trajectories typically correspond to least-action trajectories, and existence and uniqueness of these trajectories is easily demonstrated. However, for arbitrary duration problems, the stationary trajectory is not an optimizer, and in particular, there exist problem data where uniqueness does not hold. It is shown that, under certain conditions, points of non-uniqueness are isolated as a function of initial position. The conditions are verified in a classic two-body problem example. An extension of the implicit function theorem to certain cases where the usual first-order conditions are not satisfied is demonstrated and applied.

12:35-13:00 ThB3.6

Hamiltonian Based a Posteriori Error Estimation for Hamilton-Jacobi-Bellman Equations (I), pp. 372-374

Gruene, Lars — Univ. of Bayreuth
Dower, Peter M. — Univ. of Melbourne

In this talk we present a method for the a posteriori error estimation of the numerical solution to Hamilton-Jacobi-Bellman PDEs related to infinite horizon optimal control problems. The method uses the residual of the Hamiltonian, i.e., it checks how good the computed numerical solution satisfies the PDE and computes the difference between the numerical and the exact solution from this mismatch. We present results both for discounted and for undiscounted problems, which require different mathematical techniques. For discounted problems, an inherent contraction property can be used while for undiscounted problems an asymptotic stability property of the optimally controlled system is exploited.

ThB4 Room 2502

Networked Control Systems I (Regular Session)

Chair: Mirkin, Leonid — Technion-IIT
Co-Chair: Hayakawa, Tomohisa — Tokyo Inst. of Tech

10:30-10:55 ThB4.1

A Relaxed Maximum Entropy Approach to Robust Network Routing, pp. 375-378

Chen, Yongxin — Univ. of Minnesota
Georgiou, Tryphon T. — Univ. of Calfifornia, Irvine
Pavon, Michele — Univ. Di Padova
Tannenbaum, Allen — Stony Brook Univ

We consider network routing under random link failures with a desired final distribution. We provide a mathematical formulation of a relaxed transport problem where the final distribution only needs to be close to the desired one. The problem is a maximum entropy problem for path distributions with an extra terminal cost. We show that the unique solution may be obtained solving a generalized Schroedinger system. An iterative algorithm to compute the solution is provided. It contracts the Hilbert metric with contraction ratio less than 1/2 leading to extremely fast convergence.

10:55-11:20 ThB4.2

Solving Network Linear Equations with Quantized Node Communications, pp. 379-380

Lei, Jinlong — Pennsylvania State Univ
Yi, Peng — WUSTL
Shi, Guodong — The Australian National Univ
Anderson, Brian D.O. — Australian National Univ

In this paper, we consider a multiagent network system to solve a linear equation with quantized communication and distribution computation. We proposed a novel adaptive quantizer and an encoder-decoder design such that the linear equation could be solved by the agents with just quantized communication in a distributed manner.

11:20-11:45 ThB4.3

Anti-Windup Scheme for Networked Proportional-Integral Control, pp. 381-386

Sadeghi, Hamed — Lund Univ
Pates, Richard — Lund Univ
Rantzer, Anders — Lund Univ

We propose an anti-windup scheme for a class of control problems. This class, includes networked systems, where each node contains a subsystem and each edge comprise a control action. The networked anti-windup control system is proposed to address the issues caused by integrator state saturation. We show that the suggested control scheme is input-output stable. Furthermore, we provide a numerical method for robust performance analysis of the suggested control system.

11:45-12:10 ThB4.4

Wireless Networked Control Facing Combined Effects of Disturbance and Jamming Interference, pp. 387-392

Cetinkaya, Ahmet — Tokyo Inst. of Tech
Ishii, Hideaki — Tokyo Inst. of Tech
Hayakawa, Tomohisa — Tokyo Inst. of Tech

We explore the networked control problem under the effects of disturbance and jamming attacks. Specifically, we consider the scenarios where an insecure wireless communication channel is used for transmission of the control input packets from the controller to the plant. This channel is assumed to face jamming attacks and the likelihood of transmission failures on this channel depends on the power of the jamming interference signal emitted by an attacker. We show that the combined effects of the jamming attacks and the disturbance can cause instability even if the attacked system without disturbance is stable. Furthermore, we show that stability under jamming and disturbance can be achieved if the average jamming interference power is restricted in a certain way.

12:10-12:35 ThB4.5

H2 Optimization under Communication Interruptions, pp. 393-398

Mirkin, Leonid — Tec Hnion-IIT

The paper studies the problem of the H2 (LQG) optimal control of LTI plants under irregular communication interruptions between the sensor- and actuator-side parts of the controller. The derived optimal solution is analytic, numerically simple, implementable, transparent, and requires no a priori information about the interruption intervals or their statistics. The result is generalized to incorporate a constant loop delay.

12:35-13:00 ThB4.6

Private State Estimation for Cyber-Physical Systems Using Semi-Homomorphic Encryption, pp. 399-404

Zamani, Mohsen — Univ. of Newcastle
sadeghikhorrami, ladan — Shiraz Univ
Safavi, Ali Akbar — Shiraz Univ
Farokhi, Farhad — The Univ. of Melbourne

This paper is concerned with challenges involved with implementation of a private observer in networked control systems. Here, a secure Luenberger observer over a network is considered. The Paillier encryption, which is a semi-homomorphic encryption method, is employed so that the algebraic calculations required for the estimation can be performed over the encrypted data. This enhances the security of the state estimation process. In particular, we study the challenges associated with implementation of such a private observer on digital processors with limited memory sizes. We provide conditions under which the stability of the implemented private observer is ensured. A numerical example is utilized to demonstrate the theoretical results.

ThB5 Room 2503

Nonlinear Systems and Control I (Regular Session)

Chair: van der Schaft, Arjan J. — Univ. of Groningen
Co-Chair: Padoan, Alberto — Univ. of Cambridge

10:30-10:55 ThB5.1

A Symplectic Formulation of Open Thermodynamic Systems, pp. 405-407

van der Schaft, Arjan J. — Univ. of Groningen
Maschke, Bernhard — Univ. Claude Bernard of Lyon

In this work we expand on the symplectic formulation of thermodynamic systems exposed in our recent work, and inspired by previous work of Balian and Valentin. The main novel contribution is the geometric formulation of open thermodynamic systems as a homogeneous Lagrangian submanifold of the product of the symplectified thermodynamic phase space and a space of external variables. This leads to a natural property of shifted passivity to be used for analysis and control. Furthermore, it will be discussed how this homogeneous Lagrangian submanifold admits a natural (singular) Riemannian metric.

10:55-11:20 ThB5.2

On the Notion of Moment at a Pole of a Nonlinear System, pp. 408-413

Padoan, Alberto — Univ. of Cambridge
Astolfi, Alessandro — Imperial Coll. London

The notion of moment at a pole of a single-input, single-output, continuous-time, nonlinear, time-invariant system is studied. It is argued that the existing notion of moment at pole can be extended to wider classes of systems. The moment at a pole of a class of systems in feedback form is shown to be uniquely determined by the steady-state impulse response of the system under weaker assumptions than those of previous works. With a class of asymptotically autonomous systems as a guiding example, it is shown that general invariant manifolds (which do not necessarily pass through the origin) can be also used to characterise moments at a pole. Finally, a dual notion of moment at a pole is introduced and shown to be “natural” for systems in feedforward form.

11:20-11:45 ThB5.3

Constructing Flat Inputs for Two-Output Systems, pp. 414-421

Nicolau, Florentina — ENSEA
Respondek, Witold — INSA De Rouen
Barbot, Jean Pierre — ENSEA

In this paper, we study the problem of constructing flat inputs for two-output dynamical systems. The notion of flat inputs has been introduced by Waldherr and Zeitz (2008, 2010) and can be seen as a dual perspective for that of flat outputs. In the single-output case, a flat input can be constructed if and only if the original system together with its output is observable. In the multi-output case, the observability is not necessary for the construction of the flat inputs. We start by discussing (from the point of view of minimal differential weight) the case when the dynamical system together with the given output is observable and we present a generalization of the results of Waldherr and Zeitz (2010). Then, we give our main results. We consider the unobservable case for which we study the local and global problems. We completely describe the local case, discuss the issue of the minimal perturbation of the original system, and propose a solution for the global problem. Finally, we explain how our results can be applied to secure communication.

11:45-12:10 ThB5.4

Dominance Analysis of Linear Complementarity Systems, pp. 422-428

Miranda-Villatoro, Felix Alfredo — Univ. of Cambridge
Forni, Fulvio — Univ. of Cambridge
Sepulchre, Rodolphe J. — Univ. of Cambridge

The paper extends the concepts of dominance and p-dissipativity to the non-smooth family of linear complementarity systems. Dominance generalizes incremental stability whereas p-dissipativity generalizes incremental passivity. The generalization aims at an interconnection theory for the design and analysis of switching and oscillatory systems. The approach is illustrated by a detailed study of classical electrical circuits that switch and oscillate.

12:10-12:35 ThB5.5

Fliess Operator Representations of Markov Jump Nonlinear Systems and Their Parallel Interconnections, pp. 429-434

Duffaut Espinosa, Luis Augusto — Univ. of Vermont
Gray, W. Steven — Old Dominion Univ

This paper provides a Fliess operator representation for a class of continuous-time Markov jump nonlinear systems. This representation allows one to describe the parallel sum and product interconnections of such systems. The paper concludes by showing that all parallel interconnections preserves rationality when the component operators have rational generating series.

12:35-13:00 ThB5.6

Asymptotically Stabilizing Controller Generating Sparse Input for Nonlinear Systems, pp. 435-440

Yamashita, Yuh — Hokkaido Univ
Sakano, Kiminori — Hokkaido Univ
Kobayashi, Koichi — Hokkaido Univ

In this report, we propose an asymptotically stabilizing controller using a control Lyapunov function (clf). The proposed controller generates a sparse input vector, when no input constraint is active, for energy savings. For the cases with no input constraint, the control law can be described explicitly in a variant of Sontag-type controller. When some input constraints are subjected to the system, the control input can be obtained by solving an LP problem. The controller makes the time derivative of the clf negative, if possible. Otherwise, an input minimizing the time derivative of the clf is chosen, where all inputs are saturated. We have also proposed a chattering-suppression mechanism. The effectiveness of the proposed method is confirmed by computer simulations.

ThB6 Room 2504

Optimization I (Regular Session)

Chair: Rantzer, Anders — Lund Univ
Co-Chair: Zhang, Wei — Ohio State Univ

10:30-10:55 ThB6.1

H-Infinity Optimal Adaptive Control for First Order Systems, pp. 441-442

Rantzer, Anders — Lund Univ

Given a dynamic plant with parametric uncertainty, we present a causal state feedback law, that minimizes the worst case input-output l2-gain. The control law is adaptive in the sense the past data is used to estimate model parameters for prediction of future dynamics. The given formula recovers standard H-infinity optimal state feedback when the parametric uncertainty shrinks to zero.

10:55-11:20 ThB6.2

Optimal Mass Transport for Regularizing Inverse Problems Using Generalized Sinkhorn Iterations, pp. 443-446

Karlsson, Johan — Royal Inst. of Tech. (KTH)
Ringh, Axel — KTH Royal Inst. of Tech

The optimal mass transport problem has recently gained significant interest in application areas such as signal processing, image processing, and computer vision. Although the problem can be phrased as a linear program, in many cases the resulting optimization problem is intractable due to the vast number of variables. This issue was recently addressed by introducing a perturbation in terms of an entropic barrier term and solving the resulting optimization problem using Sinkhorn iterations. In this extended abstract we extend this to incorporate a class of optimization problems involving an optimal transport cost. In particular we show that the proximal operator of the optimal transport cost can be computed, also for large problems, using Sinkhorn-type iterations. By using a splitting framework, this is then used to solve inverse problems where the optimal mass transport cost is used for incorporating a priori information. We illustrate the method on a problem in limited angle computerized tomography, where a priori information is used to compensate for missing measurements.

11:20-11:45 ThB6.3

Distributed Multi-Agent Optimization for Pareto Optimal Problem Over Unbalanced Networks Via Exact Penalty Methods with Equality and Inequality Constraints, pp. 447-452

Masubuchi, Izumi — Kobe Univ
Wada, Takayuki — Osaka Univ
Fujisaki, Yasumasa — Osaka Univ
Dabbene, Fabrizio — Pol. Di Torino

This paper proposes a distributed multi-agent optimization protocol to solve a Pareto optimal problem. The protocol only requires local communications between agents to exchange decision variables and the graph representing the communications has to be only strongly connected but does not need to be balanced. This extends the implementability of the protocol to real-world applications. The protocol is based on exact penalty methods and can handle inequality and equality constraints. The computation is executed without disclosing objective and constraint functions.

11:45-12:10 ThB6.4

Optimization Perspectives of Mean-Field Games, pp. 453-459

Li, Sen — Univ. of California at Berkeley
Zhang, Wei — Ohio State Univ

This paper studies the connections between mean-field games and an auxiliary optimization problem, and compares the auxiliary optimization with potential functions. We formulate a large-population game in function space. The cost functions of all agents are weakly coupled though the mean of the population states/controls. We show that under some conditions, the $epsilon$-Nash equilibrium of the mean-field game is the optimal solution to an auxiliary optimization problem, and this is true even when the optimization problem is non-convex. The result enables us to evaluate the mean-field equilibrium, and also has some interesting implications on the existence, uniqueness and computation of the mean-field equilibrium. While the auxiliary optimization is similar to the potential function in potential games, we show that in general, the mean-field game considered in this paper is not a potential game. We compare the auxiliary optimization problem with potential function minimization, and discuss their differences in terms of solution concept and computation complexity.

12:10-12:35 ThB6.5

Graph Learning for Regularized Low-Rank Matrix Completion, pp. 460-467

Dong, Shuyu — Univ. Catholique De Louvain
Absil, Pierre-Antoine — Univ. Catholique De Louvain
Gallivan, Kyle — Florida State Univ

Low rank matrix completion is the problem of recovering the missing entries of a large data matrix by using the low-rankness assumption. Much attention has been put recently to exploiting correlations between the column/row entities, through side information or data adaptive models, to improve the matrix completion quality. In this paper, we propose a novel graph learning algorithm and apply it to the learning of a graph adjacency matrix from a given, incomplete data matrix, in a way such that the weighted graph edges encode pairwise similarities between the rows/columns of the data matrix. Subsequently we present a graph-regularized low-rank matrix completion method. Experiments on synthetic and real datasets show that this regularized matrix completion approach achieves significant improvement for the matrix completion task.

12:35-13:00 ThB6.6

On the Primal-Dual Dynamics of Support Vector Machines, pp. 468-474

Kosaraju, Krishna Chaitanya — Indian Inst. of Tech. Madras
Mohan, Shravan — Indian Inst. of Tech. Madras
Pasumarthy, Ramkrishna — Indian Inst. of Tech. Madras

The aim of this paper is to study the convergence of the primal-dual dynamics pertaining to Support Vector Machines (SVM). The optimization routine, used for determining an SVM for classification, is first formulated as a dynamical system. The dynamical system is constructed such that its equilibrium point is the solution to the SVM optimization problem. It is then shown, using passivity theory, that the dynamical system is global asymptotically stable. In other words, the dynamical system converges onto the optimal solution asymptotically, irrespective of the initial condition. Simulations and computations are provided for corroboration.

ThB7 — Room 5506

Modeling and Estimation (Regular Session)

Chair: Huang, Minyi — Carleton Univ

10:30-10:55 ThB7.1

Fault Detection for Cyber-Physical Systems: Smart Grid Case, pp. 475-481

Silvestre, Daniel — Inst. Superior Técnico
Hespanha, Joao P. — Univ. of California, Santa Barbara
Silvestre, Carlos — Univ. of Macau

The problem of fault detection and isolation in cyber-physical systems is growing in importance following the trend to have an ubiquitous presence of sensors and actuators with network capabilities in power networks and other areas. In this context, attacks to power systems or other vital components providing basic needs might either present a serious threat or at least cost a lot of resources. In this paper, we tackle the problem of having an intruder corrupting a smart grid in two different scenarios: a centralized detector for a portion of the network and a fully distributed solution that only has limited neighbor information. For both cases, differences in strategies using Set-Valued Observers are discussed and theoretical results regarding a bound on the maximum magnitude of the attacker's signal are provided. Performance is assessed through simulation, illustrating, in particular, the detection time for various types of faults in IEEE testbed scenarios.

10:55-11:20 ThB7.2

Risk-Sensitive Performance Criteria and Robustness of Quantum Systems with a Relative Entropy Description of State Uncertainty, pp. 482-488

Vladimirov, Igor G. Australian National Univ
Petersen, Ian R. Australian National Univ
James, Matthew R. Australian National Univ

This paper considers links between the original risk-sensitive performance criterion for quantum control systems and its recent quadratic-exponential counterpart. We discuss a connection between the minimization of these cost functionals and robustness with respect to uncertainty in system-environment quantum states whose deviation from a nominal state is described in terms of the quantum relative entropy. These relations are similar to those in minimax LQG control for classical systems. The results of the paper can be of use in providing a rational choice of the risk-sensitivity parameter in the context of robust quantum control with entropy theoretic quantification of statistical uncertainty in the system-field state.

11:20-11:45 ThB7.3

Linear Quadratic Mean Field Games -- Part I: The Asymptotic Solvability Problem, pp. 489-495

Huang, Minyi Carleton Univ
Zhou, Mengjie Carleton Univ

This paper investigates the so-called asymptotic solvability problem in linear quadratic (LQ) mean field games. The model has asymptotic solvability if for all sufficiently large population sizes, the corresponding game has a set of feedback Nash strategies subject to a mild regularity requirement. We provide a necessary and sufficient condition and show that in this case the solution converges to a mean field limit. This is accomplished by developing a re-scaling method to derive a low dimensional ordinary differential equation (ODE) system, where a non-symmetric Riccati ODE has a central role.

11:45-12:10 ThB7.4

Ruelle-Bowen Continuous-Time Random Walk, pp. 496-499

Chen, Yongxin Univ. of Minnesota
Georgiou, Tryphon T. Univ. of Calfifornia, Irvine
Pavon, Michele Univ. Di Padova

We define the probability structure of a continuous-time time-homogeneous Markov jump process, on a finite graph, that represents the continuous-time counterpart of the so-called Ruelle-Bowen discrete-time random walk. It constitutes the unique jump process having maximal entropy rate. Moreover, it has the property that, given the number of jumps between any two specified end-points on the graph, the probability of traversing any one of the alternative paths that are consistent with the specified number of jumps and end-points, is the same for all, and thereby depends only on the number of jumps and the end-points and not the particular path being traversed.

12:10-12:35 ThB7.5

Cooperative Linear-Quadratic Mean Field Control and Its Hamiltonian Matrix Analysis, pp. 500-502

Chen, Xiang Carleton Univ
Huang, Minyi Carleton Univ

This paper studies the existence and uniqueness of a solution to linear quadratic (LQ) mean field social optimization problems with uniform agents. We exploit a Hamiltonian matrix structure of the associated ordinary differential equation (ODE) system and apply a decomposition method to find the solution; this is facilitated by solving a Riccati equation via Schur vectors where the state weight matrix may not be positive semi-definite. We further extend the decomposition method to LQ mean field games.

12:35-13:00 ThB7.6

Characterization of Isothermal CO2 Sorption Columns by Simultaneous Spatiotemporal Modeling of Transient Capacity and Heat Flow, pp. 503-506

Yang, Manda Pennsylvania State Univ
Wang, Linxi The Pennsylvania State Univ
Rioux, Robert The Pennsylvania State Univ
Armaou, Antonios The Pennsylvania State Univ

We relax several assumptions in the model from our previous work that was published in 2016 to model isothermal CO2 adsorption columns based on breakthrough curves and calorimetry measurements. The unknown parameters in the models are determined by minimizing the integral in time of the squared difference between the model prediction and experimental measurement. In a previous effort, only the CO2 adsorption behavior was used to develop the model. In this work, we include calorimetry data to improve the model. Based on the simulation result and theoretical prediction, we conclude that physical adsorption and/or elementary reactions may need to be considered in the model.

ThD1 Room 2463

Coding Theory: Coding and Convolutional Codes (Invited Session)

Chair: Pinto, Raquel Univ. of Aveiro
Co-Chair: Rosenthal, Joachim Univ. of Zurich
Organizer: Han, Guangyue The Univ. of Hong Kong
Organizer: Pinto, Raquel Univ. of Aveiro
Organizer: Rosenthal, Joachim Univ. of Zurich

16:00-16:25 ThD1.1

Faster Decoding of Rank-Metric Convolutional Codes (I), pp. 507-510

Napp, Diego Univ. of Aveiro
Pinto, Raquel Univ. of Aveiro
Rosenthal, Joachim Univ. of Zurich
Vettori, Paolo Univ. of Aveiro

Constant-dimension subspace codes, which are one of the basic tools in Random Linear (One-Shot) Network Coding, can be easily obtained by lifting rank metric codes. Analogously, convolutional codes for Multi-Shot Network Coding can be based on rank metric convolutional codes. The Authors already established a general framework for the latter kind of codes, defining a suitable (rank) distance, deriving a Singleton-like upper bound, and showing its tightness by means of the concrete construction of Maximum Rank Distance (MRD) convolutional codes. However, the decoding process, that depends on the Viterbi algorithm, may suffer from computational issues. In this contribution, an equivalent construction of a "systematic" rank metric convolutional code will be presented, which permits to simplify both the encoding and the decoding procedures. In particular, the trellis (and, therefore, the decoding) complexity can be reduced under some assumptions on the error patterns.

16:25-16:50 ThD1.2

Separation Set Distance for 2D Convolutional Codes (I), pp. 511-514

Iglesias Curto, José Ignacio Univ. of Salamanca
Napp, Diego Univ. of Aveiro
Perea, Carmen Univ. Miguel Hernández De Elche
Pinto, Raquel Univ. of Aveiro
Simoes, Rita Univ. of Aveiro

In this paper we address the problem of extending the well-known notion of column distance of one-dimensional (1D) convolutional codes to the context of multidimensional (nD) convolutional codes. In particular, we treat the 2D case and propose a new and more general notion than the one previously introduced in this context. We derive upper bounds on the distances that lead to the novel notion of

Maximum Separation Set Distance Profile 2D convolutional codes. This notion naturally extends the notion of Maximum Distance Profile 1D convolutional code. Characterizations in terms of the sliding parity-check matrices are presented.

16:50-17:15 ThD1.3

Convolutional Codes Over Bursty Erasure Channels with Low Decoding Delay (I), pp. 515-517

Napp, Diego — Univ. of Aveiro
Requena, Veronica — Univ. of Alicante

In this preliminary work we investigate the burst erasure-correction capabilities of convolutional codes. In particular, we focus on the class of encoders that admit the shortest possible decoding delay to recover all bursts of erasures of a given length for a given rate. A new simple class of such encoders is presented.

17:15-17:40 ThD1.4

List Decoding of Linear Codes Over Z_{p^r}, pp. 518-520

Napp, Diego — Univ. of Aveiro
Toste, Marisa — Inst. Pol. De Coimbra
Pinto, Raquel — Univ. of Aveiro

In this work we study the problem of list decoding of block codes over finite rings over the erasure channel. We provide explicit formulas for the list decoding size of a linear code over Z_{p^r} and show that this number is determined by the number of independent columns of a series of matrices obtained from the p-adic decomposition of a parity-check matrix of the code. The result is constructive in the sense that it can lead to an algorithm for list decoding of these codes. This work can be considered as a first step toward the study of list decoding over more difficult channels and codes, e.g., convolutional codes.

ThD2 — Room 2464

Positivity, Factorizations, and State Space Realizations for Scalar and Matrix Variables II (Invited Session)

Chair: Ball, Joseph A. — Virginia Tech
Co-Chair: Kuhlmann, Salma — Univ. of Konstanz
Organizer: Ball, Joseph A. — Virginia Tech
Organizer: Helton, J. William — UC San Diego
Organizer: Klep, Igor — The Univ. of Auckland
Organizer: Vinnikov, Victor — Ben Gurion Univ. of the Negev

16:00-16:25 ThD2.1

The Infinite Dimensional Bounded Real Lemma for Bicausal Systems (I), pp. 521-524

Ball, Joseph A. — Virginia Tech
Groenewald, Gilbert — North-West Univ
ter Horst, Sanne — North-West Univ

The Bounded Real Lemma, i.e., the state-space LMI characterization (referred to as Kalman-Yakubovich-Popov or KYP inequality) of when an input/state/output linear system satisfies a dissipation inequality, has recently been studied for infinite-dimensional discrete-time systems in a number of different settings. Here we focus on the Bounded Real Lemma in the context of infinite dimensional, discrete-time, bicausal systems. The transfer functions for such systems need not be stable, and as a result, one expects the solution to the KYP inequality to be only selfadjoint, and not (strictly) positive definite as in the classical case. This indeed turns out to be the case for the bicausal systems we consider. By a variation on Willems' storage-function approach, we prove variations on the standard and strict Bounded Real Lemma, leading to a minimal and maximal solution for the KYP inequality.

16:25-16:50 ThD2.2

The Moment Problem for the Real Polynomial Algebra in Infinitely Many Variables (I), pp. 525-526

Kuhlmann, Salma — Univ. of Konstanz

The univariate moment problem is an old problem with origins tracing back to work of Stieltjes. The multivariate moment problem has been considered more recently. Even more recently, there has been considerable interest, for both pure theory and applications, in the infinite-variate moment problem, dealing with the moment problem in infinitely many variables. Most of the work has been done so far for the case where the moment functional in question is continuous for a certain topology. In this talk, based on the work of Ghasemi, Kuhlmann, and Marshall 2016 we deal systematically with the general case without any continuity assumptions. The main new concept that we introduce and develop to this end is that of a constructibly Radon measure on the (infinite dimensional) real vector space. The talk will focus on presenting an infinite dimensional generalization of Haviland's theorem in this setting.

16:50-17:15 ThD2.3

Realizations of NC Rational Functions Around a Matrix Centre: A Generalization of the Fliess-Kronecker Theorem (I), pp. 527-528

Porat, Motke — BGU, Ben Gurion Univ

It is well known that every noncommutative (nc) rational function, of finitely many variables, that is regular at the origin admits a minimal realization and that the stable extended domain of the function is equal to the invertibility set of the pencil of the minimal realization. In addition, a nc power series around the origin will be the power series expansion of a nc rational function if and only if a given Hankel matrix built from the coefficients of the given power series has a finite rank (Fliess-Kronecker).

We present the generalizations of these two results to the case of any nc rational functions, i.e., nc rational functions that are regular at some arbitrary tuple. Those generalizations give a characterization of all nc rational functions, first in terms of their realizations and second in terms of their power series expansions.

17:15-17:40 ThD2.4

Commuting Operators Over Pontryagin Spaces with Applications to System Theory (I), pp. 529-530

Pinhas, Ariel — Ben Gurion Univ. of the Negev

In this talk we extend the vessel theory, or equivalently, the theory of overdetermined $2D$ systems to the Pontryagin space setting. The associated transfer function becomes a mapping with a finite number of negative squares between certain vector bundles defined on a compact Riemann Surface. Furthermore, we present a realization theorem of these mappings. In particular, we develop an indefinite version of the de Branges Rovnyak spaces over real compact Riemann surfaces, i.e. reproducing kernel Pontryagin spaces of analytic sections defined on real compact Riemann surfaces.

ThD3 — Room 2465

Analysis and Synthesis of Positive Systems (Invited Session)

Chair: Ebihara, Yoshio — Kyoto Univ
Co-Chair: Ogura, Masaki — Nara Inst. of Science and Tech
Organizer: Ebihara, Yoshio — Kyoto Univ

16:00-16:25 ThD3.1

LTI System Analysis Via Conversion to Externally Positive Systems: Order Reduction Via Elimination and Duplication Matrices (I), pp. 531-536

Ebihara, Yoshio — Kyoto Univ

Recently the author has shown an analysis technique of general, not necessarily positive, LTI systems via conversion to externally positive systems. More precisely, the author established a construction method of an externally positive system whose impulse response is given by the square of the original LTI system to be analyzed. Then, it has been proved that the H2 norm computation problem of a general LTI system of order n can be reduced into the L-infinity-induced norm

computation problem of an externally positive system of order n^2. On the basis of these preceding results, in this study, we show that the order of the externally positive system can be reduced up to n(n+1)/2 by using the elimination and duplication matrices that are intensively studied by Jan R. Magnus in the 80's. In addition to the computational complexity reduction in dealing with the H2 analysis, we show that such construction of externally positive systems with reduced order is quite effective in semidefinite-programming-based peak value analysis of impulse responses of general LTI systems.

16:25-16:50 ThD3.2

Resource Allocation for Containing Epidemics from Temporal Network Data (I), pp. 537-542

Ogura, Masaki	Nara Inst. of Science and Tech
Harada, Junichi	Nara Inst. of Science and Tech

We study the problem of containing epidemic spreading processes in temporal networks. We specifically focus on the problem of finding a resource allocation to suppress epidemic infection, provided that an empirical time-series data of connectivities between nodes is available. Although this problem is of practical relevance, it has not been clear how an empirical time-series data can inform our strategy of resource allocations, due to the computational complexity of the problem. In this direction, we present a computationally efficient framework for finding a resource allocation that satisfies a given budget constraint and achieves a given control performance. The framework is based on convex programming and, moreover, allows the performance measure to be described by a wide class of functionals called posynomials with nonnegative exponents. We illustrate our theoretical results using a data of temporal interaction networks within a primary school.

16:50-17:15 ThD3.3

Analysis of Performance and State-Feedback Design for MJLS in Polyhedral Cones (I), pp. 543-550

chen, ying	Nanjing Univ. of Science and Tech
Bolzern, Paolo	Pol. Di Milano
Colaneri, Patrizio	Pol. Di Milano
Bo, YM	NJUST
Du, Baozhu	Nanjing Univ. of Science and Tech

This paper deals with Markov Jump Linear Systems (MJLS) with the state constrained in a polyhedral cone. This class of systems can be seen as the generalization of Positive MJLS (where the cone is the positive orthant of the state space). First, we provide results on the analysis of some relevant performance indices, including the expected L1 norm of the impulse response. The problem of state-feedback design preserving cone-invariance and stability while guaranteeing an upper bound of such a performance index is also tackled. Two different solutions are worked out. The first one is based on nonlinear programming but has the advantage of providing a full parametrization of all admissible gains. The second solution is based on linear programming but is more conservative. Some numerical examples are presented to show the effectiveness of these design procedures.

17:15-17:40 ThD3.4

Structured Linear Quadratic Control for Transportation (I), pp. 551-553

Heyden, Martin	Lund Univ
Pates, Richard	Lund Univ
Rantzer, Anders	Lund Univ

We study a linear quadratic control problem for a transportation problem on a directed line graph. We show that the solution to the Riccati equation associated with this problem is highly structured. The feedback law is almost triangular, and the synthesis of the feedback law is given by a recursion, making it scalable. The structure of the feedback law also allows for an efficient realization of the controller using a local communication scheme.

17:40-18:05 ThD3.5

L_{infty}-Gain Analysis of Discrete-Time Positive Periodic Systems (I), pp. 554-556

Zhu, Bohao	The Univ. of Hong Kong
Lam, James	Univ. of Hong Kong
Ebihara, Yoshio	Kyoto Univ

This paper investigates the L_{infty}-gain of discrete-time positive periodic systems. By applying the lifting approach, the positive periodic system is transformed into a linear time-invariant positive system. Then based on the L_{infty}-gain characterization of a time-invariant positive systems, an equivalent condition to describe the L_{infty}-gain of positive periodic systems is given. Furthermore, a state-feedback periodic controller to guarantee stability and L_{infty}-gain of the system is obtained by solving linear inequalities. Finally, numerical examples are given to illustrate the theoretical results.

ThD4 Room 2502

Input-To-State Stability of Distributed Parameter Systems (Invited Session)

Chair: Mironchenko, Andrii	Univ. of Passau
Co-Chair: Zheng, Jun	Southwest Jiaotong Univ
Organizer: Jacob, Birgit	Bergische Univ. Wuppertal
Organizer: Mironchenko, Andrii	Univ. of Passau

16:00-16:25 ThD4.1

Small-Gain Stability Analysis of Parabolic-Hyperbolic PDE Loops (I), pp. 557-561

Karafyllis, Iasson	National Tech. Univ. of Athens
Krstic, Miroslav	Univ. of California at San Diego

Parabolic-hyperbolic PDE loops present unique features because they combine the finite signal transmission speed of hyperbolic PDEs with the unlimited signal transmission speed of parabolic PDEs. Since there are many possible interconnections that can be considered, it is difficult to give results for a “general case”. The present work focuses on two particular cases, which are analyzed in detail.

The first case is the feedback interconnection of a parabolic PDE with a special first-order hyperbolic PDE: a zero-speed hyperbolic PDE. Thus the action of the hyperbolic PDE resembles the action of an ODE. However, the study of this particular loop is of special interest because it arises in an important application: the movement of chemicals underground. Moreover, the study of this system can be used for the analysis of wave equations with Kelvin-Voigt damping.

The second case is the feedback interconnection of a parabolic PDE with a first-order hyperbolic PDE by means of a combination of boundary and in-domain terms. The interconnection is effected by linear, non-local terms. The study of this case is motivated by the boundary feedback stabilization problem for a system of hyperbolic, first-order PDEs. The study of robustness of the closed-loop system with respect to neglected diffusion phenomena leads to this specific parabolic-hyperbolic PDE loop. The obtained results for this case can also be used for the derivation of delay-independent stability conditions for parabolic PDEs with delayed, nonlocal terms.

For both cases, we provide results for existence/uniqueness of solutions as well as sufficient conditions for ISS or exponential stability in the spatial sup norm. The proof procedures of the obtained results are similar in both cases: a small-gain methodology.

16:25-16:50 ThD4.2

Input-To-State Stability with Respect to Different Boundary Disturbances for Burgers' Equation (I), pp. 562-569

Zheng, Jun	Southwest Jiaotong Univ
Zhu, Guchuan	Ec. Pol. De Montreal

This paper presents two methods for the establishment of ISS estimates in L^q-norm ($qgeq 2$) for Burgers' equation with

different types of boundary disturbances. Precisely, for Burgers' equation with Dirichlet boundary conditions, we use De~Giorgi iteration and Lyapunov method by adequately splitting the original problem into two subsystems to establish the ISS estimates in L^q-norm with some $qgeq 2$. Whereas, for Burgers' equation with certain nonlinear boundary conditions involving spacial derivatives of the solution, we obtain the ISS estimates in L^2-norm and L^q-norm with any $qgeq 2$ by some variations of Sobolev embedding inequalities that can be used to deal with the boundary items involved in Lyapunov functionals-based analysis.

16:50-17:15 ThD4.3

Stabilization of Port-Hamiltonian Systems by Nonlinear Boundary Control in the Presence of Disturbances (I), pp. 570-575

Schmid, Jochen — Univ. of Würzburg
Zwart, Hans — Univ. of Twente

In this note, we are concerned with the stabilization of linear port-Hamiltonian systems on an interval (a,b) (for instance, vibrating strings or beams) in the presence of external disturbances. In order to achieve stabilization we couple the system to a nonlinear dynamic boundary controller whose output is allowed to be corrupted by an external disturbance before it is fed back into the system. We first establish the well-posedness of the resulting closed-loop system and then present two input-to-state stability results for the closed-loop system (with input being the external disturbance): for a special class of nonlinear controllers, we obtain uniform input-to-state stability and for a more general class of nonlinear controllers, we obtain weak input-to-stability. Also, in both cases we get convergence of all solutions to zero.

17:15-17:40 ThD4.4

Local Input-To-State Stabilization of 1-D Linear Reaction-Diffusion Equation with Bounded Feedback (I), pp. 576-581

Tanwani, Aneel — CNRS
Marx, Swann — LAAS/CNRS
Prieur, Christophe — CNRS

The problem of robust stabilization with bounded feedback control is considered for a scalar reaction-diffusion system with uncertainties in the dynamics. The maximum value of the control input acting on one of the boundary points has to respect a given bound at each time instant. It is shown that, if the initial condition and the disturbance satisfy certain bounds (computed as a function of the bound imposed on the control input), then the proposed control respects the desired saturation level and renders the closed-loop system locally input-to-state stable, that is, the trajectories with certain bound on the initial condition converge to a ball parameterized by certain norm of the disturbance.

17:40-18:05 ThD4.5

Characterizations of Input-To-State Practical Stability for Finite-Dimensional and Infinite-Dimensional Systems (I), pp. 582-585

Mironchenko, Andrii — Univ. of Passau

For a broad class of infinite-dimensional systems, we characterize input-to-state practical stability (ISpS) using the uniform limit property and in terms of input-to-state stability. We specialize our results to the systems with Lipschitz continuous flows and evolution equations in Banach spaces. Even for the special case of ordinary differential equations our characterizations of ISpS via the limit property are novel and improve existing criteria for ISpS.

ThD5 Room 2503

Control of Distributed Parameter Systems (Regular Session)

Chair: Macchelli, Alessandro — Univ. of Bologna
Co-Chair: Paunonen, Lassi — Tampere Univ. of Tech

16:00-16:25 ThD5.1

A Partial Internal Model for Approximate Robust Output Regulation of Boundary Control Systems, pp. 586-591

Humaloja, Jukka-Pekka — Tampere Univ. of Tech
Paunonen, Lassi — Tampere Univ. of Tech
Kurula, Mikael — Abo Akademi Univ

Introduced for finite-dimensional systems by Francis and Wonham in the mid 70's, the internal model principle states that a stabilizing controller achieves asymptotic output tracking and disturbance rejection robustly if and only if it contains a p-copy of the exosystem frequencies, where p is the dimension of the output space of the plant. Later, the internal model principle has been extended, e.g., to boundary control systems on multidimensional spatial domains, and in this setting it follows from the principle that every robust output regulator is necessarily infinite-dimensional. However, it was recently established by the authors that robust emph{approximate} output tracking can be achieved with a finite-dimensional controller, and in the present paper, we formulate an internal model for this purpose. The efficiency of the method is numerically demonstrated using the heat equation on the unit square in $mathbb R^2$ with boundary control and boundary observation.

16:25-16:50 ThD5.2

Brayton-Moser Formulation of Distributed Port-Hamiltonian Systems. Modelling and Boundary Control, pp. 592-599

Macchelli, Alessandro — Univ. of Bologna

In this paper, for a class of linear, distributed port-Hamiltonian systems defined on a one-dimensional spatial domain, an equivalent Brayton-Moser formulation is obtained. The dynamic is expressed as a gradient equation with respect to a new storage function, the "mixed-potential," with the dimensions of power, and the system is passive with respect to a supply rate related to the reactive power. The Brayton-Moser representation is the starting point for the synthesis of boundary control laws whose effect on the system is to shape the mixed-potential function. The general theory is illustrated with the help of an example, namely the boundary stabilisation of longitudinal vibrations of a beam with internal dissipation.

16:50-17:15 ThD5.3

Structured Discretization of the Heat Equation: Numerical Properties and Preservation of Flatness, pp. 600-607

Kotyczka, Paul — Tech. Univ. München

We show the application of a recently presented structure-preserving semi-discretization method to the heat equation on an arbitrary dimensional spatial domain. It retains the separation of the geometric (Stokes-)Dirac structure with its global balance equation, from the dynamics and constitutive equations. On the 1D example, we exploit the banded structure of the resulting state space matrices in order to analyze the approximation quality of the eigenvalues for two representative parametrizations. We show that the spatial discretization scheme preserves also a given flat output as a basis for feedforward motion planning.

17:15-17:40 ThD5.4

Uniform Boundary Stabilization of the Schrödinger Equation with a Nonlinear Delay Term in the Boundary Conditions, pp. 608-609

Ghechamm, Wassila — Batna 2 Univ
Rebiai, Salah-Eddine — Univ. of Batna 2
Sidi Ali, Fatima Zohra — Batna 2 Univ

We consider the Schrödinger equation in a bounded domain of Rn with a delay term in the nonlinear boundary feedback. Under suitable assumptions, we prove global existence of the solutions by the arguments of nonlinear semigroup theory. Moreover, we obtain uniform decay rates for the solutions by following an approach that is based on certain integral inequalities for the energy functional and a comparison theorem that relates the asmptotic behaviour of the energy and of the solutions to a dissipative ordinary differential

equation.

17:40-18:05 ThD5.5

Adaptive Model Reduction and Control for Distributed Parameter Systems Using DEIM/DAPOD Combination, pp. 610-613

Yang, Manda — Pennsylvania State Univ
Armaou, Antonios — The Pennsylvania State Univ

The output feedback control of distributed parameter systems (DPS) based on adaptive model reduction is explored in this paper. A significant computational hurdle when using model reduction for control is the numerical integration of integrals that appear in the reduced order model reducing their applicability when dealing with nonlinearities. The objective of this paper is to further reduce the computational cost in discrete adaptive proper orthogonal decomposition (DAPOD). It is addressed by using discrete empirical interpolation method (DEIM) in the observer and controller to reduce the computational cost associated with the computation of nonlinear functions. The proposed method is successfully applied in a tubular reactor with recycle.

ThD6 Room 2504

Optimization II (Regular Session)

Chair: Peet, Matthew Monnig — Arizona State Univ
Co-Chair: Wang, Fu-Cheng — National Taiwan Univ

16:00-16:25 ThD6.1

Optimal Transport for Gaussian Mixture Models, pp. 614-617

Chen, Yongxin — Univ. of Minnesota
Georgiou, Tryphon T. — Univ. of Calfifornia, Irvine
Tannenbaum, Allen — Stony Brook Univ

An optimal mass transport framework on the space of Gaussian mixture models is presented. These models are widely used in statistical inference. We treat such models as discrete measures on the space of Gaussian densities. Our method leads to a natural way to compare and interpolate Gaussian mixture models, with low computational cost. The method represents a first attempt to study optimal transport problems for probability densities with specific structure that can be suitably exploited.

16:25-16:50 ThD6.2

A Dynamic Programming Approach to Evaluating Multivariate Gaussian Probabilities, pp. 618-625

Jones, Morgan — Arizona State Univ
Peet, Matthew Monnig — Arizona State Univ

We propose a method of approximating multivariate Gaussian probabilities using dynamic programming. We show that solving the optimization problem associated with a class of discrete-time finite horizon Markov decision processes with non-Lipschitz cost functions is equivalent to integrating a Gaussian functions over polytopes. An approximation scheme for this class of MDP's is proposed and explicit error bounds under the supremum norm for the optimal cost to go functions are derived.

16:50-17:15 ThD6.3

Vibration Suppression of Milling Machine Tools by the Inerter, pp. 626-630

Wang, Fu-Cheng — National Taiwan Univ
Lee, Chung-Hao — National Taiwan Univ

This paper discusses vibration suppression of milling machine tools by the inerter. There are two traditional methods to repress the cutting vibration of milling machines: the passive and the active approaches. The former normally applies mechanical networks consisting of the masses, dampers and springs. However, the mass element is not a genuine two-terminal network element and might restrict the achievable performance of the mechanical networks. Therefore, the inerter is invented to substitute the mass element. This paper investigates the benefits of the inerter in improving the vibration responses of milling machines. First, we conduct identification experiments to obtain the model of a milling machine. Second, we design three passive suspension layouts to illustrate the benefits of the inerter in suppressing the cutting vibration. Last, we conduct experiments to demonstrate the effectiveness of the inerter in improving the manufacturing performance of the milling machine.

17:15-17:40 ThD6.4

Electricity Price Dynamics in the Smart Grid: A Mean-Field-Type Game Perspective, pp. 631-636

Djehiche, Boualem — KTH
Barreiro-Gomez, Julian — New York Univ. Abu Dhabi (NYUAD)
Hamidou, Tembine — NYU

In this paper a profit optimization between electricity producers is formulated. The problem is described by a linear jump-diffusion system of conditional mean-field type where the conditioning is with respect to common noise and a quadratic cost functional involving the second moment, the square of the conditional expectation of the control actions of the producers. We provide semi-explicit solution of the corresponding mean-field-type game problem with common noise. The equilibrium strategies are in state-and-conditional mean-field feedback form, where the mean-field term is the conditional price given the realization of the global uncertainty.

17:40-18:05 ThD6.5

Convergence Analysis of Accelerated First-Order Methods for Phase Retrieval, pp. 637-640

Xiong, Huaqing — The Ohio State Univ
Chi, Yuejie — Carnegie Mellon Univ
Hu, Bin — Univ. of Wisconsin-Madison
Zhang, Wei — Ohio State Univ

Phase retrieval finds many applications in signal processing, and recently, there has been a growing interest in directly solving it via nonconvex optimization. Under certain generic statistical models, the loss function satisfies the so- called Regularity Condition (RC) in a local neighborhood of the true signal, which guarantees the linear convergence of gradient descent if initialized properly. However, accelerated first-order methods (e.g. Nesterov's method and Heavy-ball method), despite the empirical success, currently lack similar performance guarantees as the unaccelerated counterpart. This paper studies the convergence of accelerated first-order methods in phase retrieval using tools from robust control. We derive a set of Linear Matrix Inequalities (LMIs) that can be used to numerically certify linear convergence of accelerated first- order methods under the Regularity Condition. For the Heavy- ball method, analytical conditions of algorithmic parameters for linear convergence are further obtained.

FrB1 Room 2463

Coding Theory: Coding Theory and Applications (Invited Session)

Chair: Westerbäck, Thomas	Aalto Univ
Co-Chair: Ravagnani, Alberto	Univ. Coll. Dublin
Organizer: Han, Guangyue	The Univ. of Hong Kong
Organizer: Pinto, Raquel	Univ. of Aveiro
Organizer: Rosenthal, Joachim	Univ. of Zurich

10:30-10:55 FrB1.1

On the Polymatroidal Structure of Quasi-Uniform Codes with Applications to Heterogeneous Distributed Storage (I), pp. 641-647

Westerbäck, Thomas	Aalto Univ
Grezet, Matthias	Aalto Univ
Freij-Hollanti, Ragnar	Tech. Univ. of Munich
Hollanti, Camilla	Aalto Univ

Recent research on distributed storage systems (DSSs) has revealed interesting connections between locally repairable codes (LRCs) and their associated matroids and polymatroids. In this paper we define L-polymatroids - polymatroids with an added length function - in order to consider completely general LRCs in that they are defined as subsets of A^E = A_1 x ... x A_n, where each A_i is some arbitrary finite set. Earlier research in this area has only considered codes over non-mixed alphabets, i.e., A_1 = ... = A_n.

10:55-11:20 FrB1.2

Matrix Codes with the Rank-Metric and Their Covering Radii (I), pp. 648-651

Ravagnani, Alberto	Univ. Coll. Dublin
Byrne, Eimear	Univ. Coll. Dublin

The covering radius of a rank-metric code is defined as the maximum distance between the code and a matrix from the ambient space. This fundamental parameter measures the performance of a code both in error correction and source coding applications. In this paper we discuss some structural properties of matrix codes endowed with the rank metric, and relate them to the covering radius. In particular, we derive upper bounds on the covering radius of a rank-metric code by applying different combinatorial methods.

11:20-11:45 FrB1.3

A Simple State-Space Realization Method for a Class of Periodic Encoders (I), pp. 652-654

Pereira, Ricardo	Univ. of Aveiro
Rocha, Paula	Univ. of Porto
Napp, Diego	Univ. of Aveiro

Convolutional codes are an important type of error correcting codes that can be represented as a time-invariant discrete linear system over a finite field . Since the seminal work of Costello, time-varying convolutional codes raised a great interest as they can attain larger free distance than the time-invariant ones with equivalent parameters.

In this work we aim at investigating time-varying convolutional codes from a system theoretical point of view. In particular, we study the realization of periodic encoders by means of periodic state-space models with the aim of efficient implementation. More concretely, in this preliminary work we focus on period two and investigate under which conditions a given periodic encoder obtained by alternating two time-invariant encoders can be realized by a periodic state-space system. We first observe that, in general, one cannot expect to obtain a periodic state-space realization by means of the individual realizations of each associated time-invariant encoders. However, we give conditions for such procedure to hold. The presented results are illustrated by examples.

11:45-12:10 FrB1.4

A New Metric for Multi-Shot Network Coding (I), pp. 655-658

Napp, Diego	Univ. of Aveiro
Requena, Veronica	Univ. of Alicante
Climent, Joan-Josep	Univ. of Alicante

In this paper we study convolutional codes in the context of multi-shot network coding. Within this context, several classes of rank metric convolutional codes have been recently proposed in the literature. The metric considered so far in this context is the so-called sum rank distance, which makes the unnecessary assumption that the natural delay in the transmission (due, for instance, to the delay of the nodes) is so small that can be disregarded. In this work we introduce a new metric that overcomes this restriction and therefore is suitable to handle networks with delays. We shall call it the column rank distance.

FrB2 Room 2464

Further Developments and Applications of Multidimensional Systems (Invited Session)

Chair: Galkowski, Krzysztof	Univ. of Zielona Gora
Co-Chair: Azevedo Perdicoulis, Teresa Paula	ISR-Coimbra & UTAD
Organizer: Galkowski, Krzysztof	Univ. of Zielona Gora
Organizer: Azevedo Perdicoulis, Teresa Paula	ISR-Coimbra & UTAD
Organizer: Rocha, Paula	Univ. of Porto
Organizer: Rogers, Eric	Univ. of Southampton
Organizer: Pakshin, Pavel	Nizhny Novgorod State Tech. Univ
Organizer: Patan, Maciej	Univ. of Zielona Gora

10:30-10:55 FrB2.1

A Finite Difference Scheme for Iterative Learning Control Oriented Modelling of Physical Systems Described by PDEs in Polar Coordinates (I), pp. 659-665

Augusta, Petr	Czech Acad. of Sciences
Cichy, Blazej	Univ. of Zielona Gora
Galkowski, Krzysztof	Univ. of Zielona Gora
Rogers, Eric	Univ. of Southampton

Iterative learning control is a well established area of research and application, with a relatively short time between the development of the theory and design algorithms and experimental validation. This form of control is especially suitable for applications where the system is required to make repeated executions of a finite duration task with resetting to the starting location at the end of each execution. The majority of the theory and designs are for systems described by finite dimensional differential or discrete systems but there is increasing interest in the extension to systems described by partial differential equations, where for most applications, approximate finite dimensional models of the dynamics are required. The construction of such models is the subject of this paper, where the developments are in terms of systems whose dynamics are described by a fourth-order partial differential equation and the use of regular hexagonal grid and polar coordinates. The scheme is motivated by the well-known Crank-Nicolson discretization that was originally developed for first-order systems and the stability of the resulting finite-difference scheme is analyzed by von Neumann method. Using the new scheme, a discrete in time and space model of a deformable mirror is derived as the basis for control law design. The convergence of this scheme for various values of the discretization parameters is checked by numerical simulations.

10:55-11:20 FrB2.2

Converse Stability Theorems for 2D Systems (I), pp. 666-670

Pakshin, Pavel	Nizhny Novgorod State Tech. Univ
Emelianova, Julia	Arzamas Pol. Inst. of R.E.

	Alekseev Nizhny Novgorod S
Galkowski, Krzysztof	Univ. of Zielona Gora
Rogers, Eric	Univ. of Southampton

The paper considers 2D discrete nonlinear systems described by either the Fornasini-Marchesini or Roesser state-space models. Converse stability theorems are developed, which establish that, if an example is exponentially stable, there exists a vector Lyapunov function with particular properties of its entries and the discrete counterpart of divergence. The extension of these results to some class of stochastic models are also given.

Key words: Multidimensional systems, Fornasini-Marchesini model, Roesser model, converse stability theorems, vector Lyapunov functions

AMS subject classifications: 93D05, 93D30, 93E15

11:20-11:45 FrB2.3

Stability Analysis and Stabilization of the Subclass of Symmetric Spatially Interconnected Systems (I), pp. 671-676

Sulikowski, Bartlomiej	Univ. of Zielona Gora, Inst. Control and Computation Eng
Galkowski, Krzysztof	Univ. of Zielona Gora
Rogers, Eric	Univ. of Southampton
Kummert, Anton	Univ. of Wuppertal

This paper develops new results on the stability and stabilization of symmetric active ladder circuits, which are a class of spatially interconnected systems. Ladder circuits can be considered as two--dimensional systems constituted as a homogenous (in the node structure and/or in parameters of nodes values) sequence of nodes (or cells) where information is propagated in two separate directions, i.e., along the time axis and along a space variable represented by a node number. In contrast to previous research in this general area, the independent energy source is placed in the center of the ladder. A~new two-dimensional systems state-space model is developed for this case, leading to a new equivalent linear time-invariant model in one indeterminate obtained by applying a form of lifting along the nodes. Using this model description, the problems of stability testing and stabilization are addressed in a linear matrix inequality setting. A numerical case study is also given to illustrate the application of the new results.

11:45-12:10 FrB2.4

Reduction of Wave Linear Repetitive Processes to 2-D Singular State Space Form (I), pp. 677-682

Galkowski, Krzysztof	Univ. of Zielona Gora
Boudellioua, Mohamed S.	Sultan Qaboos Univ

In this paper, a method is given that reduces a polynomial system matrix describing a discrete wave linear repetitive process to an equivalent 2-D singular Fornasini-Marchesini (SFM) model. It is shown that the transformation linking the original polynomial system matrix with its associated 2-D SFM form is zero coprime system equivalence. The exact nature of the resulting system matrix in singular form and the transformation involved are established.

12:10-12:35 FrB2.5

On the State Space Realization of 2D (2, 2)-Periodic Image Behaviors (I), pp. 683-687

Aleixo, José Carlos	Univ. of Beira Interior
Napp, Diego	Univ. of Aveiro
Pereira, Ricardo	Univ. of Aveiro
Pinto, Raquel	Univ. of Aveiro
Rocha, Paula	Univ. of Porto

In this paper we consider 2D behaviors with periodic image representations and provide conditions under which a simple method for obtaining state space realizations by means of 2D periodic (separable) Roesser models can be applied. For the sake of simplicity we restrict our attention to the $(2,2)$-periodic case.

12:35-13:00 FrB2.6

Comparing Finite Differences Methods for Gas Network Simulation (I), pp. 688-691

Azevedo Perdicoulis, Teresa Paula	ISR-Coimbra & UTAD
Almeida, Regina	Univ. De Trás-Os-Montes E Alto Douro
Lopes dos Santos, P.	Univ. Do Porto

This is a study in gas modelling and simulation with a special focus on the simulation of a gas pipeline, the most important element of the network, which is represented by a quasi-hyperbolic PDE, linearised around operational levels. Different numerical schemata are presented for the solution of this problem, explicit and implicit, as well as cell centered discretisation methods. In order to have a well-posed initial-boundary value problem (IBVP), we use two-port network transfer function models to calculate the initial value function. The numerical methods are implemented in Matlab, and we give special relevance to issues as consistency, stability and convergence. Furthermore, we apply each of the schemata to calculate the solution of a pipeline. The present work is part of a research study to evaluate comparatively different numerical methods for the solution of gas network models, in particular the hyperbolic model. We start with a isothermal, one-dimensional gas flow and considering horizontal pipelines.

FrB3 Room 2465

Stochastic Approaches and Hamilton-Jacobi Equations (Invited Session)

Chair: McEneaney, William	Univ. of California, San Diego
Co-Chair: Kaise, Hidehiro	Osaka Univ
Organizer: McEneaney, William	Univ. of California, San Diego
Organizer: Dower, Peter M.	Univ. of Melbourne

10:30-10:55 FrB3.1

Hamilton-Jacobi Partial Differential Equations with Path-Dependent Terminal Costs under Superlinear Lagrangians (I), pp. 692-699

Kaise, Hidehiro	Osaka Univ
Kato, Takashi	Association of Mathematical Finance Lab
Takahashi, Yusuke	National Federation of Workers and Consumers Insurance Cooperati

We consider variational problems with path-dependent terminal costs. Motivated from Mogulskii's theorem in large deviation theory and dynamic importance sampling for path-dependent rare events, we focus on particular forms of Lagrangians with superlinear growth. By reformulating the variational problem to a value function of a path-dependent deterministic control, we study it by path-dependent dynamic programming methods. Under co-invariant derivative notion on path spaces, the value function is related to a Hamilton-Jacobi partial differential equation (PDE) with a path-dependent terminal condition. Using a viscosity type solution proposed by Lukoyanov for a weak notion, we show that the value function can be characterized as a unique viscosity solution of the Hamilton-Jacobi PDE.

10:55-11:20 FrB3.2

Solvability of the Non-Linear Dirichlet Problem with Integro-Differential Operators (I), pp. 700-701

Song, Qingshuo	City Univ. of Hong Kong
Bayraktar, Erhan	Univ. of Michigan

This work studies the solvability of a class of Dirichlet problem associated with non-linear integro-differential operator. The main ingredient is the probabilistic construction of continuous supersolution via the identification of the continuity set of the exit time operators

under Skorohod topology.

11:20-11:45 FrB3.3

An Action Principle for Constructing Fundamental Solution Groups for Wave Equations (I), pp. 702-704

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

By exploiting connections between stationary action and optimal control, fundamental solution groups corresponding to a class of wave equations are constructed via dynamic programming.

11:45-12:10 FrB3.4

Convergent Collocation Methods for Hamilton-Jacobi-Bellman Equations (I), pp. 705-706

Nakano, Yumiharu Tokyo Inst. of Tech

We report a convergence result of kernel-based collocation methods for Hamilton-Jacobi-Bellman equations. In particular, we find the class of kernels and the structure of collocation points explicitly under which the process of iterative interpolation is stable, and show that the functions constructed by the collocation methods converge to a unique viscosity solution of the Hamilton-Jacobi-Bellman equations.

12:10-12:35 FrB3.5

Stationarity-Based Representation for the Coulomb Potential and a Diffusion Representation for Solution of the Schrodinger Equation (I), pp. 707-709

McEneaney, William Univ. of California, San Diego

Diffusion representations have long been utilized in the study of Hamilton-Jacobi partial differential equations (HJ PDEs). The bulk of such results apply to real-valued HJ PDEs, that is, to HJ PDEs where the coefficients and solutions are real-valued. The Schrodinger equation is complex-valued, although generally defined over a real-valued space domain, which presents difficulties for the development of stochastic control representations. The approach considered here is in the spirit of the Feynman path-integral interpretation where in particular, one looks at a certain action-based functional. We obtain a representation for the Maslov dequantization of the solution in the form of a value function for a complex-valued diffusion where the action functional is the payoff. Previous efforts required a potential possessing a holomorphic extension. Here, a staticization-based representation for the Coulomb potential is used to bypass such a requirement.

FrB4 Room 2502

Networked Control Systems II (Regular Session)

Co-Chair: Morita, Ryosuke Gifu Univ

10:30-10:55 FrB4.1

Noise-Induced Limitations to the Scalability of Distributed Integral Control, pp. 710-713

Tegling, Emma KTH Royal Inst. of Tech
Sandberg, Henrik KTH Royal Inst. of Tech

We study performance limitations of distributed feedback control in large-scale networked dynamical systems. Specifically, we address the question of how the performance of distributed integral control is affected by measurement noise. We consider second-order consensus-like problems modeled over a toric lattice network, and study asymptotic scalings (in network size) of H2 performance metrics that quantify the variance of nodal state fluctuations. While previous studies have shown that distributed integral control fundamentally improves these performance scalings compared to distributed proportional feedback control, our results show that an explicit inclusion of measurement noise leads to the opposite conclusion. The noise's impact on performance is shown to decrease with an increased inter-nodal alignment of the local integral states. However, even though the controller can be tuned for acceptable performance for any given network size, performance will degrade as the network grows, limiting the scalability of any such controller tuning. In particular, the requirement for inter-nodal alignment increases with network size. We show that this in practice implies that large and sparse networks will require any integral control to be centralized, rather than distributed. In this case, the best-achievable performance scaling, which is shown to be that of proportional feedback control, is retrieved.

10:55-11:20 FrB4.2

Optimal Denial-Of-Service Attack Sequence with Energy Constraint Over Lossy Networks, pp. 714-715

Li, Menglin Univ. of Science and Tech. of China
Qin, Jiahu Univ. of Science and Tech. of China

A novel method is proposed for solving the optimal Denial-of-Service (DoS) attack scheduling problem against remote state estimation with energy constraint over the lossy network. The optimal attack scheduling sequence that maximizes the average expected estimation error over lossy networks is derived. Details of the technique are outlined.

11:20-11:45 FrB4.3

Linear Quadratic Optimal Control of Jump System Over Multiple Erasure Channels, pp. 716-721

Mazumdar, Abhijit Indian Inst. of Tech. Guwahati
Krishnaswamy, Srinivasan IIT Guwahati
Majhi, Somanath Indian Inst. of Tech. Guwahati

This paper considers the design of linear quadratic optimal controller for Markovian jump linear systems (MJLSs) over multiple lossy communication channels with correlated packet loss. Considering the Gilbert-Elliott channel model which takes into account the temporal correlation of the data packet losses, the finite horizon controller and the infinite horizon controller are designed under TCP-like protocol. Existence of the infinite horizon controller is investigated by analyzing convergence of the cost function. Further, we derive the finite horizon and the infinite horizon controller for a linear time invariant (LTI) system as a special case. Finally, for the infinite horizon case, we demonstrate the dependence of the convergence of the optimal cost on the control packet arrival probability.

11:45-12:10 FrB4.4

Distributed Obstacle Avoidance-Formation Control of Mobile Robotic Network with Coordinated Group Stabilization, pp. 722-725

Chan, Nelson P.K. Univ. of Groningen
Jayawardhana, Bayu Univ. of Groningen
Scherpen, Jacquelien M.A. Fac. Science and Engineering, Univ. of Groningen

We present a distributed control law for a group of agents that solves the problem of formation control with obstacle avoidance and that can be combined with a coordinated group stabilization control law. In particular, we consider a control law that is given by a linear combination of distributed formation, distributed obstacle avoidance and centralized group motion control laws. Simulation results show the effectiveness of our proposed control law.

12:10-12:35 FrB4.5

Weak Consensus with Discrete-Valued Input and the Performance Dependency on Its Network Topology, pp. 726-728

Morita, Ryosuke Gifu Univ
Ito, Satoshi Gifu Univ

This paper presents a new consensus algorithm for multi-agent systems with discrete-valued input. The algorithm is designed with consideration that the convergence speed does not degrade. The relation between the performance of the algorithm and the network topology of the system is analyzed.

12:35-13:00 FrB4.6

Exponential Synchronization of Lohe Oscillators with Strongly Connected Topologies, pp. 729-733

Zhang, Jinxing — Nanjing Normal Univ

Zhu, Jiandong — School of Mathematical Sciences, Nanjing Normal Univ

Lohe model is a typical dynamic network of nonlinear multi-agent systems. Under strongly connected topologies, the synchronization problem of Lohe oscillators is investigated. The obtained results show that, limited on a half unit sphere, synchronization of Lohe model can be achieved. To analyze exponential synchronization, a matrix Riccati differential equation of synchronization errors is proposed for the first time. It is proved that, after a finite amount of time, the synchronization errors converge to zero exponentially.

FrB5 Room 2503

Nonlinear Systems and Control II (Regular Session)

Chair: Mironchenko, Andrii — Univ. of Passau

Co-Chair: Qian, Chunjiang — Univ. of Texas at San Antonio

10:30-10:55 FrB5.1

Integral Uniform Global Asymptotic Stability and Non-Coercive Lyapunov Functions, pp. 734-741

Mironchenko, Andrii — Univ. of Passau

Wirth, Fabian R. — Univ. of Passau

In this paper, a class of abstract dynamical systems is considered which encompasses a wide range of nonlinear finite- and infinite-dimensional systems. We show that the existence of a non-coercive Lyapunov function without any further requirements on the flow of the forward complete system ensures an integral version of uniform global asymptotic stability. We prove that also the converse statement holds without any further requirements on regularity of the system.

Furthermore, we give a characterization of uniform global asymptotic stability in terms of the integral stability properties and analyze which stability properties can be ensured by the existence of a non-coercive Lyapunov function, provided either the flow has a kind of uniform continuity near the equilibrium or the system is robustly forward complete.

10:55-11:20 FrB5.2

Asymptotic Stability of a Class of Nonlinear Systems Admitting Homogeneity with Strictly Decreasing Degrees, pp. 742-746

Zhu, Jiandong — School of Mathematical Sciences, Nanjing Normal Univ

Qian, Chunjiang — Univ. of Texas at San Antonio

Asymptotic stability is investigated for a class of inherently nonlinear systems admitting homogeneity with strictly decreasing degrees (HSDD). By using the technique of homogeneous domination and the concept of HSDD, a concrete Lyapunov/Chetaev function is constructively obtained. Then, by Lyapunov Stability Theorem and Chetaev Instability Theorem, a necessary and sufficient condition for the asymptotic stability is proposed. Finally, simulations are given to validate the theoretical result.

11:20-11:45 FrB5.3

Distributed Recursive Filter for Systems with Multiplicative Noises, pp. 747-752

He, Xingkang — Acad. of Maths and Systems Sci, Chinese Acad. of Sciences

Qian, Liu — The Key Lab. of Systems and Control, Inst. of Systems S

Fang, Haitao — Acad. of Mathematics and Systems Science, Chinese Acad. Of

This paper studies the distributed state estimation problem for a class of linear time-invariant (LTI) systems with multiplicative noises over multi-agent networks. First, adaptive fusion matrices with distributed strategy is considered in terms of consistency, which provides an upper bound for mean square error matrix of each agent and the bound is minimized by the designed time-varying filter gain. Based on the designed fusion matrices and filter gain, a distributed robust Kalman filter is proposed. Moreover, under mild conditions of collective observability and network topology, it is shown that the mean square error matrices of agents are uniformly upper bounded and the information matrix of the network are uniformly lower bounded by constant matrices both through finite time, which is revealed to be the summation of collective observability parameter and network scale. Finally, the asymptotic unbiasedness of the estimation of each agent is shown. Numerical simulation shows the effectiveness of the proposed algorithm.

11:45-12:10 FrB5.4

A Mathematics Approach to Improve the Computational Efficiency of Economic-Oriented Model Predictive Control, pp. 753-759

Fang, Yizhou — The Pennsylvania State Univ

Armaou, Antonios — The Pennsylvania State Univ

In this paper, we propose a mathematics approach to improve the computational efficiency of economic-oriented model predictive control (EMPC). We approximate the nonlinear dynamic system with a Two-tier method: 1) Approximate the system through Taylor expansion and obtain a polynomial formulation; 2) Expand the polynomial formulation through Carleman approximation (also known as Carleman linearization) and arrive at an extended bilinear expression. This expression has a bilinear form but carries information of higher order dynamics. In this way, we save simulation efforts by predicting the future economic performances with analytical solutions. We also save optimization efforts by providing the sensitivity of the economic performances to the manipulated inputs as the search gradient. Hence, despite the economic stage costs are mostly non-tracking and non-quadratic, we achieve significant acceleration in the computation of EMPC. An oxidation of ethylene reactor is demonstrated as the application example. We optimize three manipulated inputs and establish a non-tracking cyclic operation. The improvement in computational efficiency is presented by comparison with standard EMPC method.

12:10-12:35 FrB5.5

Study on Stability of General Discrete-Time Stochastic Difference Systems, pp. 760-761

jiang, xiushan — South China Univ. of Tech

zhang, tianliang — South China Univ. of Tech

Zhang, Weihai — Shandong Univ. of Sci. and Tech

In order to improve the previous results and obtain efficient criteria for discrete stochastic stability, new techniques should be introduced. In this paper, by using Doob's martingale theory and stopping time theorem for supermartingale, we have successfully generalized some classical stability theorems existing in It^o systems to general discrete stochastic system, which are expected to be useful in stochastic H_infty control and network control.

12:35-13:00 FrB5.6

Dynamic Output Feedback Invariants of Full Relative Degree Nonlinear SISO Systems, pp. 762-768

Gray, W. Steven — Old Dominion Univ

Duffaut Espinosa, Luis Augusto — Univ. of Vermont

The goal of this paper is to explicitly describe invariants of a plant described by a Chen--Fliess series under a class of dynamic output feedback laws using earlier work by the authors on feedback transformation groups. The main result requires the rather strong assumption that the plant has a generating series with both finite Lie rank and full relative degree. In which case, there is no loss of

generality in working with state space realizations of the plant. An additional genericness assumption regarding the normal form of the plant is also required, but as shown by the examples, this condition is often available in typical problems. All of the analysis presented is restricted to the single-input, single-output case.

FrB6	Room 2504
Systems on Graphs (Regular Session)	
Chair: Caines, Peter E.	McGill Univ
Co-Chair: Liu, Cheng-Lin	Jiangnan Univ

10:30-10:55 FrB6.1

Consensus-Induced Centrality for Networks of Dynamical Systems, pp. 769-775

Gao, Shuang — McGill Univ
Caines, Peter E. — McGill Univ

In multi-agent systems where agents are coupled through the underlying networks and follow the consensus dynamics, the ability for agents on networks to reach consensus depends on the network structure, and more specifically depends on the spectra of the Laplacian of the networks. Each agent on the network plays a role in aggregating the information for the agent population to reach a consensus. To evaluate the influence that one agent would have on the network to reach consensus, we propose the consensus-induced centrality measure. Examples of consensus-induced centrality analysis for different types of networks are given. The consensus-induced centrality has possible applications in many network systems, such as social networks, power grid stability and wireless sensor networks, etc.

10:55-11:20 FrB6.2

Mixing Rates for the Cycle with Structured Additional Wiring, pp. 776-778

Gerencser, Balazs — MTA Alfréd Rényi Inst. of Mathematics, ELTE Eötvös Loránd Un
Hendrickx, Julien M. — UCL

We analyze the mixing rate of a class of Markov chains where two features together help significantly speed up mixing: first, a cycle graph is enriched with extra edges in a randomized but structured way. Second, the Markov chain on the graph is taken to be asymmetric. We show a bound on the mixing rate of these Markov chains and demonstrate that both these features contribute to the outcome.

11:20-11:45 FrB6.3

Persistent-Hold Consensus Control of First-Order Multi-Agent Systems with Intermittent Communication, pp. 779-783

Liu, Cheng-Lin — Jiangnan Univ
Zhang, Ya — Southeast Univ
Chen, Yangyang — Southeast Univ

Under intermittent communication, a persistent-hold consensus algorithm is proposed to solve the consensus problem of first-order multi-agent systems. Based on matrix theory and graph theory, consensus conditions are obtained for the agents converging to the asymptotic consensus under fixed topology and switching topologies, respectively. Numerical simulations show the correctness of theoretical results.

11:45-12:10 FrB6.4

A Scheme for Computing the Transfer Function of Power Grids with Grounded Capacitors, pp. 784-786

Jeeninga, Mark — Univ. of Groningen
De Persis, Claudio — Univ. of Groningen
van der Schaft, Arjan J. — Univ. of Groningen

We consider a simple model for power grids with grounded unitary capacitors at the loads, and look at the computation of the transfer function from generator potentials to generator currents. We propose an alternative scheme for computing this transfer function.

12:10-12:35 FrB6.5

Further Study on Parameter Bound of Surplus-Based Averaging Algorithm, pp. 787-790

Kawamura, Satoshi — Osaka City Univ
Cai, Kai — Osaka City Univ
Ye, Mengbin — Australian National Univ

We study a continuous-time surplus-based algorithm for multi-agent average consensus, and derive a tight upper bound on the key parameter included in this algorithm that ensures convergence over strongly connected and balanced digraphs. Based on this result, it is suggested through extensive simulation that, for the same number of agents, the upper bound for cyclic digraphs be smaller than that for other strongly connected and possibly unbalanced digraphs; this implies that as long as the parameter satisfies the upper bound for cyclic digraphs, this parameter can work for other digraphs.

12:35-13:00 FrB6.6

Strong Input-To-State Stability for Infinite Dimensional Linear Systems (I), pp. 791-792

Nabiullin, Robert — Univ. of Wuppertal
Schwenninger, Felix Leopold — Univ. of Hamburg

FrB7	Room 5506
Advances in Multi-Agent Systems (Invited Session)	
Chair: Wang, Xinghu	Univ. of Science and Tech. of China
Organizer: Wang, Xinghu	Univ. of Science and Tech. of China
Organizer: Zeng, Xianlin	Beijing Inst. of Tech

10:30-10:55 FrB7.1

Distributed Nash Equilibrium Seeking for Non-Cooperative Games Subject to Coupled Inequality Constraints: A Time-Scale Separation Approach (I), pp. 793-798

Zou, Yao — Tsinghua Univ
Huang, Bomin — Tsinghua Univ
Meng, Ziyang — Tsinghua Univ

This paper investigates the Nash equilibrium seeking problem for non-cooperative games subject to a coupled inequality constraint. Both the local cost functions and the constrained function are mutually coupled by the decision variables of players. A distributed seeking algorithm is proposed via local information interaction. First, a distributed observer with the projection property is introduced for each player to estimate the decision variables of all the other players. By using these estimations, a seeking algorithm with the projection property is then synthesized. The stability analysis is based on a time-scale separation approach. In particular, we first show that the fast dynamics composed by the distributed observer with an appropriate parameter guarantees that the estimation errors converge to an arbitrarily small neighborhood of the origin in finite time and maintain within it afterwards. Based on this result, we further show that the slow dynamics composed by the seeking algorithm achieves the convergence of the strategy profile to a neighborhood of the generalized Nash equilibrium of interest. an illustrative example is provided to verify the theoretical results.

10:55-11:20 FrB7.2

Robust H-Infinity Time-Varying Formation Tracking for High-Order Multi-Agent Systems with External Disturbances (I), pp. 799-804

Yu, Jianglong — Beihang Univ

Dong, Xiwang — Beihang Univ
Liang, Zixuan — Beihang Univ
Li, Qingdong — Beihang Univ
Ren, Zhang — Beihang Univ

Robust H-infinity time-varying formation tracking problems for high-order multi-agent systems with matched and mismatched disturbances under directed topologies are investigated. In this paper, the followers are required to form a formation specified by a time-varying piecewise continuously differentiable vector while tracking the trajectory of the leader containing unknown control input with a H1 disturbance attenuation performance. Firstly, a distributed formation tracking protocol is put forward which is constituted by using local neighboring information. An approach to designing the protocol for high-order multi-agent systems to achieve the robust H-infinity time-varying formation tracking is proposed, where the formation tracking feasibility constraint is also derived. Stability of the closed-loop multi-agent system under the protocol is proved. Finally, the effectiveness of the theoretical results are verified by a third-order simulation example.

11:20-11:45 FrB7.3

Smooth Algorithm for Nonsmooth Convex Optimization Using Proximal Operator and Derivative Feedback (I), pp. 805-808

Zeng, Xianlin — Beijing Inst. of Tech
Chen, Jie — Beijing Inst. of Tech

This paper considers a class of nonsmooth convex optimization problems whose objective function is the summation of a twice differentiable convex function and a lower semi-continuous convex function. Using the proximal operator and derivative feedback ideas, we propose a smooth algorithm for the problem and prove the convergence and correctness of the algorithm. The design is then applied to distributed optimization problems

11:45-12:10 FrB7.4

Finite-Time Coordination Control for a Class of Second-Order Nonlinear Multi-Agent Systems (I), pp. 809-812

Li, Zhenxing — Southeast Univ
liu, zhaodong — Linyi Univ
Guochen, Pang — Linyi Univ

In this paper, we consider the distributed finite-time consensus control for a class of second-order nonlinear multi-agent systems. In order to design the finite-time consensus controller, homogeneous function was employed and a new type of distributed finite-time consensus controller was given. This kind of controller not only solves the finite-time consensus problem of leaderless second-order nonlinear multi-agent systems, but also relaxes the condition of the network topology among the agents from undirected graph or detail-balanced directed graph to strongly connected graph. In the real control engineering, the most common sensors are displacement sensor and acceleration sensor, the velocity information is not available directly. When velocity information is not available, the finite-time convergent observer is designed by using position information, and we give another kind of finite-time consensus controller for multi-agent systems based on the states of the finite-time observers.

12:10-12:35 FrB7.5

Distributed Optimization for Multi-Agent Systems of Independent Step Size (I), pp. 813-816

Wang, Dong — Dalian Univ. of Tech
Chen, Yangwei — Dalian Univ. of Tech

In this paper, we develop a distributed algorithm for multiple agents aiming to solve an optimization problem. The communication among the agents is governed by an undirected graph. In our algorithm, each agent uses an independent step-size and the upper bound of steps are independent from network topologies. The step-sizes depend on local objective functions. We present an algorithm that even with different step sizes guarantees convergence of the agent states to a common point.With such step range, the states of each agent converge to a common optimal point at a linear rate $O({kappa ^{ -k}})$ where $0<kappa<1 $ and k is the number of iterations. As compared to existing approaches, we only need the local cost function of each agent is convex rather than strongly convex. Finally, the numerical examples are given to validate the theoretical results obtained.

12:35-13:00 FrB7.6

Robust Distributed Control of Uncertain Nonlinear Vehicle Platoons (I), pp. 817-819

Zhong, bin — USTC
Wang, Xinghu — Univ. of Science and Tech. of China

This paper studies the distributed control problem of uncertain vehicle platoons. The vehicle is modelled by a third-order nonlinear longitudinal dynamics. Under general directed information flow topologies, we propose a robust distributed controller embedding adaptive laws to estimate the control gains. By using the Lyapunov method, we show that the developed control law can ensure that all the uncertain nonlinear vehicles in question track a desired speed and maintain a fixed inter-vehicle spacing.

FrD1 — Room 2463

Analysis and Control of Networked and Large-Scale Systems (Invited Session)

Chair: Cai, Kai — Osaka City Univ
Co-Chair: Vargas, Francisco J. — Univ. Técnica Federico Santa María
Organizer: Chen, Wei — The Hong Kong Uni. of Sci. and Tech
Organizer: Qiu, Li — Hong Kong Univ. of Sci. & Tech

16:00-16:25 FrD1.1

Opinion Dynamics with State-Dependent Susceptibility to Influence (I), pp. 820-823

Ye, Mengbin — Australian National Univ
Liu, Ji — Stony Brook Univ
Anderson, Brian D.O. — Australian National Univ

A general discrete-time opinion dynamics model is studied in this paper. It is proposed that each individual has a susceptibility to being influenced by his/her neighbours, and that this susceptibility depends on the individual's current opinion value. This precept is captured by a state-dependent susceptibility function. Two different susceptibility functions are proposed to describe individuals who are stubborn conformists and stubborn extremists. Stubborn conformists are individuals who become more closed to influence when they have an opinion similar to the network average, while stubborn extremists are less susceptible when they hold opinions at either end of the opinion interval. Convergence results are established for networks where all individuals are stubborn conformists, or all individuals are stubborn extremists. Simulations are provided to illustrate the results. Key conclusions, consistent with sociology literature and exemplified by the simulations are that (i) stubborn conformists typify observed phenomenon whereby it takes a long time for people to agree on social norms, and an equally difficult time breaking them, and (ii) existence of stubborn extremists can pull individuals with an initial neutral opinion to the extremes.

16:25-16:50 FrD1.2

Fundamental Limitations of Feedback and Networked Feedback Systems: An Information-Theoretic Analysis (I), pp. 824-827

Fang, Song — City Univ. of Hong Kong
Chen, Jie — City Univ. of Hong Kong
Ishii, Hideaki — Tokyo Inst. of Tech

In this extended abstract we analyze the fundamental performance limitations of feedback and networked feedback systems by

leveraging information-theoretic notions including entropy and mutual information, as an attempt towards bridging control theory and information theory. In particular, we develop Bode-type integrals, power gain bounds, and variance minimization limits applicable to information-constrained networked feedback systems, which hold for arbitrarily general controllers as long as they are causal and stabilizing. Towards this end, we propose a number of information measures such as negentropy rate, channel blurredness, and Gaussianity-whiteness compatible to control system analysis. We also investigate feedback systems without communication channels; in particular, we examine the results further in the context of state estimation. In general, the performance limitations are seen to be characterized by plant instabilities, channel noisiness, and disturbance Gaussianity-whiteness. In summary, this abstract presents a unifying information-theoretic framework for control system limitation analysis, and consolidates the role of Shannon's information theory as a mathematical theory of not only communication but also control.

16:50-17:15 FrD1.3

On Spectral Properties of Directed Scale-Free Networks (I), pp. 828-830

Imae, Takanobu — Osaka City Univ
Cai, Kai — Osaka City Univ

In this paper, we study the spectral properties of directed scale-free networks. First, we study the algebraic connectivity of a directed scale-free network, which is the eigenvalue of its Laplacian matrix whose real part is the second smallest. This is known as an important measure for the diffusion speed of many diffusion processes over networks (e.g. consensus, information spreading, epidemics). We also investigate the eigenvalue of the Laplacian matrix with maximum real part. We propose an algorithm, extending that of Barabasi and Albert, to generate directed scale-free networks, and show by simulations the relations between the spectral properties and network size, exponents of in/out-degree distributions, and minimum in/out degrees.

17:15-17:40 FrD1.4

Dynamics of Heterogeneous Mass Chains Via Repeated Compositions of Moebius Transformations (I), pp. 831-833

Yamamoto, Kaoru — Lund Univ

This note studies the disturbance amplification in an interconnected heterogeneous mass chain in which one end is connected to a movable point. Each interconnection is represented by a general mechanical impedance function. The problem arises in the design of multi-storey buildings subjected to earthquake disturbances, or bidirectional control of vehicle platoons. Recurrence relations with respect to the number of masses are derived for the scalar transfer functions from the movable point displacement to a given intermass displacement. In particular, each relation takes the form of a Moebius transformation.

17:40-18:05 FrD1.5

String Stability for Predecessor Following Platooning Over Lossy Communication Channels (I), pp. 834-837

Vargas, Francisco J. — Univ. Técnica Federico Santa María
Maass, Alejandro I. — The Univ. of Melbourne
Peters, Andres — Univ. Técnica Federico Santa María

We study a platooning scheme where the communication between agents is made through lossy channels. Each agent is modelled as a discrete-time LTI system controlled by a discrete-time LTI controller. The lossy channels are modelled using Bernoulli processes that represent random data dropouts. We consider a scheme that forces inter-vehicle spacings that increase with agents velocities. This is known as a constant time headway spacing policy, which has been shown to provide string stability for predecessor-following architectures. We analyse how the lossy channels impact the platoon string stability.

FrD2 Room 2464

Linear Systems (Regular Session)

Chair: Ohta, Yoshito — Kyoto Univ
Co-Chair: Phan, Duy — Tampere Univ. of Tech

16:00-16:25 FrD2.1

Distributed Fault Detection Observer Design for Linear Systems, pp. 838-844

Han, Weixin — Harbin Inst. of Tech
Trentelman, Harry L. — Univ. of Groningen
Wang, Zhenhua — Harbin Inst. of Tech
Shen, Yi — Harbin Inst. of Tech

This paper investigates the distributed fault detection problem for linear time-invariant (LTI) systems with distributed measurement output. We propose a distributed fault detection observer (DFDO) design method to detect actuator faults of the monitored system in the presence of a bounded process disturbance. The DFDO consists of a network of local fault detection observers, which communicate with their neighbors as prescribed by the given network graph. A systematic algorithm for DFEO design is addressed, enabling the residual to be robust against the effects of the external bounded process disturbance. Based on L_{infty} analysis, a bank of linear matrix inequalities is presented to calculate the gain matrices and residual thresholds in our distributed fault detection scheme. Finally, we illustrate the effectiveness of the proposed distributed fault detection approach by means of a numerical simulation.

16:25-16:50 FrD2.2

System Transformation Induced by Generalized Orthonormal Basis Functions Preserves Dissipativity, pp. 845-851

Ohta, Yoshito — Kyoto Univ
Rapisarda, Paolo — Univ. of Southampton

This paper discusses the dissipativity of transformed systems induced by generalized orthonormal basis functions. The dissipativity includes both passivity and the finite system gain property. We prove that the transformed system preserves the dissipativity and shares a common storage function when the original continuous-time system is dissipative. The results further illuminates the properties of this class of system transformation.

16:50-17:15 FrD2.3

Model Reduction of Linear Port-Hamiltonian Systems: A Structure Preserving Approach, pp. 852-855

Borja, Pablo — Univ. of Groningen
Scherpen, Jacquelien M.A. — Fac. Science and Engineering, Univ. of Groningen

In this note we address the problem of model reduction of a particular class of linear systems, namely, the linear port-Hamiltonian (PH) systems. Furthermore, we explore the preservation of the PH structure in the reduced model. Towards this end, we adopt the balanced truncation approach to reduced the order of the model, in particular, we study the use of extended Gramians to balance the linear PH systems. The latter provides degrees of freedom to impose a desired structure, in this case a PH one, to the reduced model. Moreover, for balanced truncation using extended Gramians, the error bound is well-known and is given in terms of the Hankel singular values of the truncated state.

17:15-17:40 FrD2.4

Robust Controllers for a Heat Equation Using the Galerkin Approximation, pp. 856-863

Phan, Duy — Tampere Univ. of Tech
Paunonen, Lassi — Tampere Univ. of Tech

We consider the robust output tracking problem for an unstable one-dimensional heat equation. As the main contribution we propose

a new way of designing finite-dimensional robust controllers based on Galerkin approximations of infinite-dimensional observer-based controllers. The results are illustrated with a concrete example where the finite-dimensional controllers are constructed using the Finite Element Method. The results are extendable for more general parabolic control systems.

17:40-18:05 FrD2.5

Toward a Decay Rate Assignment Based Design for Time-Delay Systems with Multiple Spectral Values, pp. 864-871

Boussaada, Islam — IPSA & Lab. Des Signaux Et Systèmes
Niculescu, Silviu-Iulian — Umr Cnrs 8506, Cnrs-Supelec
Trabelsi, Karim — IPSA

Recent results on maximal multiplicity induced-dominancy for spectral values in reduced-order Time-Delay Systems naturally apply in controllers design. As a matter of fact, the approach is merely a delayed-output-feedback where the candidates' delays and gains result from the manifold defining the maximal multiplicity of a real spectral value, then, the dominancy is shown using the argument principle. Various reduced order examples illustrate the applicative perspectives of the approach.

FrD3 Room 2465

Signal Processing (Regular Session)

Chair: Rao, Shodhan — Ghent Univ. Global Campus

16:00-16:25 FrD3.1

Sparse Regression Using Compressive Sensing with Input Shaping, pp. 872-878

Borkar, Vivek S. — Indian Inst. of Tech. Bombay
Dwaracherla, Vikranth — IIT Bombay
Sahasrabudhe, Neeraja — IISER Mohali

We present a compressive sensing approach for sparse regression problem and using the ideas from concentration of measure, extend it to case where the samples are generated from a Markov chain. This is achieved by constructing a matrix from samples such that it is suitable for reconstructing sparse parameter vectors via l_1-minimization.

16:25-16:50 FrD3.2

Lyapunov Functions for Michaelis Menten Approximation of Processive Phosphorylation Futile Cycles, pp. 879-884

Rao, Shodhan — Ghent Univ. Global Campus

In this paper, we analyze a class of processive phosphorylation futile cycles in which a given protein substrate is modified by more than two enzymes. This analysis is based on the assumption that the initial concentration of the protein substrate is much higher than the concentrations of the enzymes. This assumption allows us to reduce the dynamics of the system to its Michaelis Menten approximation using the steady state approach. We then prove that for the given system of equations, there exists a unique equilibrium concentration vector in every positive stoichiometric compatibility class. We further prove that this unique equilibrium is globally asymptotically stable using two different Lyapunov functions. The first Lyapunov function is a piecewise linear in rates (PWLR) Lyapunov function. The construction of the second Lyapunov function is based on the property of strict convexity of the exponential function.

16:50-17:15 FrD3.3

A New Symmetric Key Homomorphic Encryption Scheme, pp. 885-892

Dowerah, Uddipana — Indian Inst. of Tech. Guwahati
Krishnaswamy, Srinivasan — IIT Guwahati

This work describes a new Symmetric Key Homomorphic Encryption scheme. We define a noisy variant of the Subspace Membership problem called the Hidden Subspace Membership problem and show that the proposed scheme is IND-CPA secure based on the hardness of this problem. We then discuss the homomorphic properties of the proposed scheme.

17:15-17:40 FrD3.4

On the Uniqueness of Maximum Likelihood Estimation of Nuclear Sources, pp. 893-896

Haug, Josh — Univ. of Iowa
Anjum, Mohammad Fahim — Univ. of Iowa
Anderson, Brian D.O. — Australian National Univ
Dasgupta, Soura — Univ. of Iowa
Mudumbai, Raghuraman — Univ. of Iowa
Baidoo-Williams, Henry — Univ. of Iowa

In an earlier paper, cite{ITA}, we have considered the Maximum Likelihood (ML) localization of a stationary nuclear source using the time of arrival of particles modeled as a Poisson process. In this paper we consider whether the ML location estimate characterized in cite{ITA} is unique. In particular, we show that the question of uniqueness is equivalent to whether or not the root locus of a certain transfer function admits a single pair of nonzero imaginary axis crossing.

FrD4 Room 2502

Networked Control Systems III (Regular Session)

Chair: Petersen, Ian R. — Australian National Univ
Co-Chair: Li, Yuke — Yale Univ

16:00-16:25 FrD4.1

The Power Allocation Game on a Dynamic Network: Equilibrium Selection, pp. 897-900

Li, Yuke — Yale Univ
Morse, A. Stephen — Yale Univ

This note proposes two equilibrium selection methods and applies them to the power allocation game developed in cite{allocation}. The first method has the game take place on a sequence of time-varying graphs, which redefines the PAG in an extensive form game framework, and selects the subgame perfect Nash equilibria. The second method has the power allocation game take place on a different sequence of time-varying graphs and selects the ``resilient'' Nash equilibria, where the concept of ``resilience'' is taken from the literature of network security. Certain technical results as well as the link between the two methods will be discussed. Either method is also applicable to equilibrium selection problems involving other network games.

16:25-16:50 FrD4.2

Spatio-Temporal Transfer Function Conditions of Positive Realness for Translation Invariant Lattice Networks of Interacting Linear Systems, pp. 901-908

Vladimirov, Igor G. — Australian National Univ
Petersen, Ian R. — Australian National Univ

This paper is concerned with networks of interacting linear systems at sites of a multidimensional lattice. The systems are governed by linear ODEs with constant coefficients driven by external inputs, and their internal dynamics and coupling with the other component systems are translation invariant. Such systems occur, for example, in finite-difference models of large-scale flexible structures manufactured from homogeneous materials. Using the spatio-temporal transfer function of this translation invariant network, we establish conditions for its positive realness in the sense of energy dissipation. The latter is formulated in terms of block Toeplitz bilinear forms of the input and output variables of the composite system. We also discuss quadratic stability of the network in isolation from the environment and phonon theoretic dispersion relations.

16:50-17:15 FrD4.3

On a Concept of Genericity for RLC Networks, pp. 909-916

Hughes, Timothy H. Univ. of Exeter
Morelli, Alessandro Univ. of Cambridge
Smith, Malcolm C. Univ. of Cambridge

A generic network is a resistor-inductor-capacitor (RLC) network which realises a set of impedance parameters of dimension one more than the number of elements in the network. We prove that such networks are minimal, in the sense that it is not possible to realise a set of impedance parameters of dimension n with fewer than n-1 elements. We provide a necessary and sufficient condition for genericity in terms of the derivative of the mapping from element values to impedance parameters. We then prove that a network with a non-generic subnetwork is itself non-generic, and that any positive-real impedance can be realized by a generic network.

17:15-17:40 FrD4.4

A Convex Approach to the Finite Dimensional Matching Problem in Communication Systems, pp. 917-920

Bose, Gibin INRIA Sophia Antipolis
Martinez Martinez, David INRIA Sophia Antipolis
Seyfert, Fabien INRIA
Olivi, Martine INRIA

In this work, the impedance matching problem in communication systems is formulated as a convex optimization problem. Important properties of the problem including feasibility, existence and uniqueness of solution are discussed. A practical example of matching filter synthesis using this technique is presented.

17:40-18:05 FrD4.5

Stochastic Mirror Descent Algorithm Over Distributed Time-Varying Network, pp. 921-924

Wang, Yinghui Chinese Acad. of Sciences and Univ. of Chinese Acad. Of
Zhou, Hongbing Acad. of Mathematics and Systems Science, Chinese Acad. of S
Hong, Yiguang Chinese Acad. of Sciences

In this paper, we propose a stochastic mirror descent algorithm for solving distributed convex optimization problem over a distributed time-varying network. We adopt Bregman divergence rather than Euclidean distance as the augmented distance measuring function to solve the distributed onvex optimization problem. With a fixed step-size, we analyze the convergence rate of our algorithm, which is also the best known convergence rate for distributed first-order algorithms.

FrD5 Room 2503

Nonlinear Systems and Control III (Regular Session)

Chair: Karlsson, Johan Royal Inst. of Tech. (KTH)
Co-Chair: Dia, Roxana CEA-LETI

16:00-16:25 FrD5.1

A Universal Model-Free and Safe Adaptive Cruise Control Mechanism, pp. 925-932

Berger, Thomas Univ. Hamburg
Rauert, Anna-Lena Univ. Hamburg

We consider the problem of vehicle following, where a safety distance to the leader vehicle is guaranteed at all times and a favourite velocity is reached as far as possible. We introduce the funnel cruise controller as a novel universal adaptive cruise control mechanism which is model-free and achieves the aforementioned control objectives. The controller consists of a velocity funnel controller, which directly regulates the velocity when the leader vehicle is far away, and a distance funnel controller, which regulates the distance to the leader vehicle when it is close so that the safety distance is never violated. A sketch of the feasibility proof is given. The funnel cruise controller is illustrated by a simulation of three different scenarios which may occur in daily traffic.

16:25-16:50 FrD5.2

Energy-Based Stabilization of Network Flows in Multi-Machine Power Systems, pp. 933-940

Arghir, Catalin ETH Zurich
Dörfler, Florian ETH Zürich

This paper considers the network flow stabilization problem in power systems and adopts an output regulation viewpoint. Building upon the structure of a heterogeneous port-Hamiltonian model, we integrate network aspects and develop a systematic control design procedure. First, the passive output is selected to encode two objectives: consensus in angular velocity and constant excitation current. Second, the non-Euclidean nature of the angle variable reveals the geometry of a suitable target set, which is compact and attractive for the zero dynamics. On this set, circuit-theoretic aspects come into play, giving rise to a network potential function which relates the electrical circuit variables to the machine rotor angles. As it turns out, this energy function is convex in the edge variables, concave in the node variables and, most importantly, can be optimized via an intrinsic gradient flow, with its global minimum corresponding to angle synchronization. The third step consists of explicitly deriving the steady-state control action by further refining this sequence of control-invariant sets. Analogously to solving the so called regulator equations, we obtain an impedance-based network flow map leading to novel error coordinates and a shifted energy function. The final step amounts to decoupling the rotor current dynamics via feedback-linearziation resulting in a cascade which is used to construct an energy-based controller hierarchically.

16:50-17:15 FrD5.3

General Inverse Sensor Model for Probabilistic Occupancy Grid Maps Using Multi-Target Sensors, pp. 941-948

Dia, Roxana CEA-LETI
lesecq, suzanne CEA
Mottin, Julien CEA-LETI
Puschini, Diego CEA-Leti

Environment perception is a crucial task for safe navigation of robots. It relies on the robust interpretation of noisy sensor measurements. To represent the state of the surrounding environment, probabilistic Occupancy Grids are commonly used. They are built using a Bayesian inference procedure which estimates the occupancy probability of each cell in the grid from sensor readings. However, the complexity of such a procedure is exponentially increasing with the number of cells, especially when sensor readings are caused by multiple targets simultaneously. To overcome this difficulty, we propose a novel approach to handle multi-target sensors. It is based on a sectoral decomposition of their Field-Of-View under the nearest-target hypothesis, which breaks down the complexity to a linear one. Finally, a realistic implementation of the proposed formulation is presented, and an experimental construction of occupancy grids is discussed.

17:15-17:40 FrD5.4

Tracking Distributions of Linear Dynamical Systems: An Optimal Mass Transport Approach, pp. 949-952

Chen, Yongxin Univ. of Minnesota
Karlsson, Johan Royal Inst. of Tech. (KTH)

We consider the problems of tracking a set of indistinguishable agents with linear dynamics based only on output measurements. The behaviors of the agents may be modeled by distributions. We formulate the problems using optimal mass transport theory with prior linear dynamics. Though our problem has a convex formulation, with general purpose solver, it is only computationally feasible if the state dimension is low. In the case where the marginal distributions are Gaussian, the problem is reformulated as a semidefinite programming

and can be efficiently solved for large state dimension.

17:40-18:05 FrD5.5

Acceleration of Convergence While Tracking Planned Feature Trajectories for Visual Servoing, pp. 953-955

Shen, Tiantian Central South Univ
Feng, Zhiguang The Univ. of Hong Kong

This extended abstract illustrates mainly an idea for accelerating the convergence in eye-in-hand visual servoing applications. Path-planning techniques have been embedded into VS (Visual Servoing) to guide the sensor motion satisfying multiple constraints and limitations. Ahead of visual servoing, path-planning techniques can produce a series of feature trajectories, either projected from a target when the camera virtually moves along the planned camera path or directly planned in the image plane. These feature trajectories are then interpolated and tracked by an IBVS (Imaged Based VS) controller to conduct a converged VS process. In general, larger the interpolation interval or the controller gain, quicker the convergence and, unfortunately, probably larger the tracking error of the planned path and even divergence in the workspace due to image noises. This abstract aims to obtain an optimal interpolation interval under a certain interpolation policy and an associated controller gain under an upper bound of tracking error defined in the workspace to accelerate the global convergence of path-planning based VS applications.

MTNS 2018 Author Index

MTNS 2018 Keyword Index