International Workshop on
Emerging Frontiers in System and Control

Organized by
Center for Intelligent and Networked Systems, Tsinghua University
Institute of Systems Science, Chinese Academy of Sciences

Sponsored by
IEEE Control Systems Society
IEEE Control Systems Society Beijing Chapter
Tsinghua National Laboratory for Information Science and Technology

Chair: Xiaohong Guan
Co-Chair: Yiguang Hong
Program Chair: Qingshan Jia
Date: May 18 (Friday), 2012
Location: Lecture Hall of FIT Building, Tsinghua University

Agenda
08:30-09:00 Opening remarks (Prof. Guan, Prof. Hong, Prof. Cassandras)
Session 1 (Session Chair: Qing-Shan Jia)
09:00-09:40 Francesco Bullo, University of California at Santa Barbara, United States of America
Attack Detection and Identification in Cyber-Physical Systems
09:40-10:20 Xiaohong Guan, Tsinghua University, China
Security Constrained Generation Scheduling in Smart Grid: Redundancy and Feasibility
10:20-10:40 Tea break
Session 2 (Session Chair: Yiguang Hong)
10:40-11:20 Masayuki Fujita, Tokyo Institute of Technology, Japan
Cooperative Distributed Energy Management toward Smart Renewables
11:20-12:00 Daizhan Cheng, Institute of Systems Science, Chinese Academy of Sciences, China
On Game-based Control Systems
12:00-13:30 Lunch break
Session 3 (Session Chair: Qianchuan Zhao)
13:30-14:10 Richard Middleton, The University of Newcastle, Australia
2D Analysis of String Stability
14:10-14:50 Yiguang Hong, Institute of Systems Science, Chinese Academy of Sciences, China
Distributed output regulation of multi-agent systems
14:50-15:30 Panos Antsaklis, the University of Notre Dame, United States of America
Cyber-Physical Systems, Symmetry and Passivity
15:30-15:45 Tea break
Session 4 (Session Chair: Qing-Shan Jia)
15:45-16:25 Francis Doyle, University of California at Santa Barbara, United States of America
Biological Inspiration for Network Control Systems
16:25-17:05 Qianchuan Zhao, Tsinghua University, China
   Energy Efficient Building Design for a Class of Manufacturing Plants Using Ordinal Optimization
17:05-17:10 Closing remarks (Prof. Xiaohong Guan)

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NOTE: FREE LUNCH will be provided for all REGISTERED attendees! In order to reserve your free lunch, please send your name, department, university, and contact information to Mr. Zijian Wu (wuzj10@mails.tsinghua.edu.cn) for registration as soon as possible!
Abstract

SPEAKER: Francesco Bullo, University of California at Santa Barbara, United States of America
TITLE: Attack Detection and Identification in Cyber-Physical Systems
ABSTRACT: Cyber-physical systems integrate computation, communication, and physical capabilities. We propose a unified framework to analyze the resilience of cyber-physical systems against attacks cast by an omniscient adversary. We model cyber-physical systems as linear descriptor systems, and attacks as exogenous unknown inputs. Despite its simplicity, our model captures various real-world cyber-physical systems and it includes and generalizes the most studied prototypical attacks, including stealth, false-data injection and replay attacks. For this model, we study various attack detection and identification procedures, and we characterize their fundamental limitations. We provide constructive algebraic conditions to cast undetectable and unidentifiable attacks, and graph-theoretic conditions for the existence of undetectable and unidentifiable attacks. Following our analysis, we propose centralized and decentralized monitors for attack detection and identification. Finally, we present several illustrative examples that illustrate our findings, and show the effectiveness of our methods also in the presence of system noise, nonlinearities, and modeling uncertainties. This is a joint work with Fabio Pasqualetti and Florian Dorfler.

BIOSKETCH: Francesco Bullo received the Laurea degree in Electrical Engineering from the University of Padova in 1994, and the Ph.D. degree in Control and Dynamical Systems from the California Institute of Technology in 1999. From 1998 to 2004, he was affiliated with the Coordinated Science Laboratory at the University of Illinois at Urbana-Champaign. He is currently a Professor with the Mechanical Engineering Department at the University of California, Santa Barbara. His students’ papers were finalists for the Best Student Paper Award at the IEEE Conference on Decision and Control (2002, 2005, 2007), and the American Control Conference (2005, 2006, 2010). He is the coauthor of the book "Geometric Control of Mechanical Systems" (Springer, 2004) and of the book "Distributed Control of Robotic Networks" (Princeton, 2009). His main research interest is multi-agent networks with application to robotic coordination, distributed computing and power networks.
Dealing with a large number of security constraints are one of the major difficulties in generation scheduling in a large scale power grid. If the redundant security constraints, possible a large portion due to sufficient security margins, in the power grid can be identified and eliminated, the scheduling problem can be greatly simplified. In this talk, a necessary and sufficient condition for a security constraint to be redundant is presented. It is proved that all redundant constraints can be identified by solving a series of small-scale mixed integer linear programming problems. More importantly, an analytical sufficient condition is established and most of the redundant constraints can be quickly identified without solving the problem. Based on the above analysis, a group of analytical conditions for identifying the feasibility of the on/off operating states can be established. Most of these states can be quickly identified as feasible/infeasible by using these analytical conditions without solving the generation scheduling problem. The analytical conditions can be used to obtain feasible solution in Lagrangian relaxation framework, and to form efficient cutting planes in general mixed integer programming approach. This is a joint work with Prof. Qiaozhu Zhai at Systems Engineering Institute and MOE KLINNS Lab, Xian Jiaotong University.

BIOSKETCH: Professor Xiaohong Guan received his B.S. and M.S. degrees in Control Engineering from Tsinghua University, Beijing, China, in 1982 and 1985, respectively, and his Ph.D. degree in Electrical and Systems Engineering from the University of Connecticut in 1993. He was a senior consulting engineer with Pacific Gas and Electric from 1993 to 1995. He visited the Division of Engineering and Applied Science, Harvard University from Jan. 1999 to Feb. 2000. From 1985 to 1988 and since 1995 he has been with the Systems Engineering Institute at Xian Jiaotong University, Xian, China and appointed as the Cheung Kong Professor of Systems Engineering since 1999, and served the Director of the State Key Lab for Manufacturing Systems from 1999 to 2009. He has been serving the Dean of School Electronic and Information Engineering, Xian Jiaotong University since 2008. Since 2001 he has been the Director of the Center for Intelligent and Networked Systems and severed the Head of Department of Automation, Tsinghua University, 2003-2008. Professor Guan is a Fellow of IEEE, an Editor of IEEE Transactions on Power Systems, and is serving the Distinguished Lecturer of IEEE Robotics and Automation Society, 2008-.
SPEAKER: Masayuki Fujita, Tokyo Institute of Technology, Japan
TITLE: Cooperative Distributed Energy Management toward Smart Renewables
ABSTRACT: An early shift of national energy policy from nuclear power to renewables is an immediate agenda of Japan. In particular, it is aspired to establish a cooperative distributed energy management system achieving real-time total optimization and control of energy demand and supply including volatile and spatially distributed renewable energy sources. In response to the situation, expectations on systems and control technologies to develop such smart renewable systems are rapidly growing. In this talk, we first outline circumstances surrounding Japanese researchers in our field. Then, we introduce our recent research progresses on the issue using promising control methodology, cooperative control/optimization/games.
BIOSKETCH: Masayuki Fujita is a Professor with the Department of Mechanical and Control Engineering at Tokyo Institute of Technology. He received Dr. of Eng. degree in Electrical Engineering from Waseda University, Tokyo, in 1987. Prior to his appointment at Tokyo Tech, he held faculty appointments at Kanazawa University and Japan Advanced Institute of Science and Technology. His research interests include passivity-based control in robotics, applied robust control, and energy management systems. He is currently IEEE CSS Vice President Conference Activities. He has served as a member of IEEE CSS Board of Governors, and the General Chair of the 2010 IEEE Multi-conference on Systems and Control. He serves as the Head of SICE Technical Division on Control, and served as the Chair of SICE Technical Committee on Control Theory and a Director of SICE. He has served/been serving as an Associate Editor for IEEE Transactions on Automatic Control, IEEE Transactions on Control Systems Technology, IFAC Automatica, Asian Journal of Control, and an Editor for SICE Journal of Control, Measurement, and System Integration. He is a recipient of the 2008 IEEE Transactions on Control Systems Technology Outstanding Paper Award. He also received the SICE Education Award and the Outstanding Paper Awards from SICE and ISCIE. Since 2012, he is recently appointed as the Program Officer of JST (Japan Science and Technology Agency) CREST (Core Research for Evolutional Science & Technology) under the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.
SPEAKER: Daizhan Cheng, Institute of Systems Science, Chinese Academy of Sciences, China
TITLE: On Game-based Control Systems
ABSTRACT: The antagonistic game-based control systems are considered. First, the pure strategy game leads to logical dynamic system. Under both average payoff and the total with discount factor payoff, the optimal control is considered, and numerical solutions are obtained. Then the mixed strategy game, which leads to probabilistic logical dynamic systems, is considered. The method for solving optimal controls is also presented.
BIOSKETCH: Daizhan Cheng graduated from Tsinghua University in 1970, received M.S. from Graduate School, Chinese Academy of Sciences in 1981, Ph.D. from Washington University, St. Louis, in 1985. Since 1990, he is a professor with Institute of Systems Science, AMSS, CAS. His research interests include nonlinear control systems, switched systems, Hamiltonian systems and logical dynamic systems. He is the author/coauthor of 200 journal papers, 10 books and 120 conference papers. He was Associate Editor of “Int. J. Math. Sys. Est. Contr.” (90-93); “Automatica” (99-02); “Asian J. Contr.” (01-04), Subject Editor of Int. J. Rob. Nonli. Contr. (2005-2008); Chairman of Technical Committee on Control Theory, Chinese Association of Automation (03-11), Chairman of IEEE CSS Beijing Chapter(2006-2008). He is Editor-in-Chief of “J. Control Theory and Applications”(08-), Deputy Editor-in-Chief of “Control and Decision” (05-). IEEE Fellow (2005-) and IFAC Fellow (2008-). He received Second Award of National Natural Science Award in 2008, and IFAC Automatica Best Paper Award in 2011.
SPEAKER: Richard Middleton, The University of Newcastle, Australia
TITLE: 2D Analysis of String Stability
ABSTRACT: String stability issues arise in a number of dynamic systems such as vehicle platoons, supply chain management and irrigation channel control. In such systems, there is a simple (linear string) underlying graph structure, of coupled dynamic systems, where each has second order dynamics. In such cases, it is known poor behaviours can be observed in seemingly benign cases. In this talk I will show how this can be analysed from a 2D systems point of view, using a mixed continuous time - discrete time viewpoint, including some results on 2D Lyapunov stability.
BIOSKETH: Richard Middleton has focused his research on a range of quality research outcomes. He has 10 publications with more than 50 ISI citations. He has delivered plenary addresses in Singapore and Adelaide, and has been invited to be part of a 2007 NATO lectures series. He has held Associate Editor appointments in the major journals: IEEE Transactions on Automatic Control, Automatica, and IEEE Transactions on Control System Technology. He is a Fellow of IEEE and of Engineers Australia. He has received awards as Australian Telecommunications and Electronics Research Board (ATERB) Outstanding young investigator, Royal Society of NSW Edgeworth David Medl, and Engineers Australia M.A. Sargent Award. Middleton was head of Department of Electrical and Computer Engineering at the University of Newcastle. He has been a panel member, and sub-panel chair for the ARC, a vice president (2004-2007), president elect (2010), and president (2011) for the IEEE Control Systems Society, and Program Chair of the premier annual control theory conference, the IEEE Conference on Decision and Control. Middleton has been involved in 25 different industry funded research projects or consultancies, including being Technical Director on a range of Satellite Tracking projects for national and international telecommunications companies, and the Australian Defense industry.
SPEAKER: Yiguang Hong, Institute of Systems Science, Chinese Academy of Sciences, China

TITLE: Distributed Output Regulation of Multi-Agent Systems

ABSTRACT: In this talk, distributed output regulation is discussed to deal with leader–follower multi-agent control. By treating a leader to be followed as an exosystem, the proposed framework generalizes existing multi-agent coordination solutions by allowing the agents to track an active leader with different dynamics and unmeasurable variables. Based on internal model principle, necessary and sufficient conditions for the distributed output regulation problem of linear multi-agent systems are given. Moreover, distributed output regulation of some classes of multi-agent systems with switching interconnection topologies are discussed. Finally, networked internal model is introduced to reduce the complexity of control design.

BIOSKETCH: Professor Yiguang Hong received his B.Sc. and M.Sc. degrees from Peking University, and his Ph.D. degree from Institute of Systems Science, Chinese Academy of Sciences (CAS). He is currently a professor of Academy of Mathematics and Systems Science, CAS. He is the director of Key Lab of Systems & Control, CAS, and the director of Information Technology Division of National Center for Mathematics and Interdisciplinary Sciences, CAS. He also served as the associate editor of IEEE Transactions on Automatic Control, and the chairman of IEEE Control Systems Society Beijing Chapter.
SPEAKER: Panos Antsaklis, the University of Notre Dame, United States of America
TITLE: Cyber-Physical Systems, Symmetry and Passivity
ABSTRACT: Cyber-Physical Systems are characterized by large numbers of tightly integrated heterogeneous components in a network, which may expand and contract dynamically. Cyber-Physical Systems are very common and are becoming increasingly ubiquitous. Passivity and dissipativity are “energy like” concepts that may be used to guarantee properties, such as stability, in complex heterogeneous interconnected systems that are changing dynamically. Passivity and QSR-dissipativity approaches have been proposed by our group to control CPS, together with Lyapunov approaches and symmetry concepts. We use passivity indices, which provide a measure of the degree of passivity, and their relation to conic systems to generalize known results in interconnected systems. Results for continuous, discrete, switched and networked systems, together with event triggered control architectures will be shown.
BIOSKETCH: Panos Antsaklis is the Brosey Professor of Electrical Engineering at the University of Notre Dame. He also is Concurrent Professor in the Departments of Computer Science and Engineering and of Applied and Computational Mathematics and Statistics. He is a graduate of the National Technical University of Athens, Greece, and holds MS and PhD degrees from Brown University. His research addresses problems of control and automation and examines ways to design control systems that will exhibit high degree of autonomy. His recent research focuses on Cyber-Physical Systems and addresses problems in the interdisciplinary research area of control, computing and communication networks, and on hybrid and discrete event dynamical systems. He had co-authored two research monographs on discrete event systems, two graduate textbooks on Linear Systems and has co-edited six books on Intelligent Autonomous Control, Hybrid Systems and Networked Embedded Control Systems. He is IEEE, IFAC and AAAS Fellow and the 2006 recipient of the Engineering Alumni Medal of Brown University. He is the Editor-in-Chief of the IEEE Transactions on Automatic Control.
SPEAKER: Francis J. Doyle III, University of California at Santa Barbara, United States of America
TITLE: Biological Inspiration for Network Control Systems
ABSTRACT: Circadian timekeeping by intracellular molecular clocks is found throughout nature. The clockworks are driven by autoregulatory feedback loops that lead to oscillating levels of components whose maxima are in fixed phase relationships with one another. These phase relationships are the key metric characterizing the operation of the clocks. In this talk I will describe key results in capturing these behaviors with mathematical models, including their noise properties. Finally, abstractions of the biophysical models will be used to generate theorems on the interplay of local and global driving forces, and the impact on the rate of synchronization. Those results will be used to demonstrate novel protocols for the synchronization of wireless sensor networks, including networks that are dynamic (changing topology). QualNet case studies confirm the effectiveness of the synchronization strategy.

BIOSKETCH: Frank Doyle holds the Duncan and Suzanne Mellichamp Chair in Process Control in the Department of Chemical Engineering, as well as appointments in the Electrical Engineering Department, and the Biomolecular Science and Engineering Program at UC, Santa Barbara. He is the Director of the UCSB/MIT/Caltech Institute for Collaborative Biotechnologies, and is the Associate Dean for Research in the College of Engineering. He received a B.S.E. degree from Princeton, C.P.G.S. from Cambridge, and Ph.D. from Caltech, all in Chemical Engineering. Prior to his appointment at UCSB, he has held faculty appointments at Purdue University and the University of Delaware, and held visiting positions at DuPont, Weyerhaeuser, and Stuttgart University. He has been recognized as a Fellow of multiple professional organizations including: the IEEE, IFAC, AIMBE, and the AAAS. He served as the editor-in-chief of the IEEE Transactions on Control Systems Technology from 2004-2009, and is currently the Vice President for Publications in the Control System Society. In 2005, he was awarded the Computing in Chemical Engineering Award from the AIChe for his innovative work in systems biology. His research interests are in systems biology, network science, modeling and analysis of circadian rhythms, drug delivery for diabetes, model-based control, and control of particulate processes.
ABSTRACT: Energy conservation is an important way of cost control for manufacturing plants. This paper explores ways to find energy efficient building design for manufacturing plants. Many efforts have been directed into the field of building design optimization concerning building energy performance, but most of the studies focus on residential buildings or public buildings. Very limited related research studying plants buildings has been reported. However, plants buildings have some features that make the design problem more challenging. Moreover, the approaches developed in the current literature could not guarantee the performance of their solutions if the computation budget if limited. This talk tries to address these two challenges. First, an EnergyPlus-integrated overall energy consumption estimation framework is developed for a class of manufacturing plants where the environmental conditions would not affect the energy consumption of the production processes, and based on this, the building design problem for the class of manufacturing plants is formulated as a stochastic programming problem concerning uncertainties arising from the future weather conditions and energy prices. Seasonal production scheduling optimizing is also incorporated when estimating the performance of building designs. Second, Ordinal Optimization (OO) method is introduced to solve the problem so as to quantitatively guarantee a high probability of finding good enough design while reducing the computation burden. A numerical example is provided, showing our solution method acts well in finding a good design. This is a joint work with CFINS PhD Student Hao Liu, GM collaborators Dr. Ninja Huang and Dr. Xiang Zhao.

BIOSKETCH: Qianchuan Zhao received the B.E. degree in automatic control in July 1992, the B.S. degree in applied mathematics in July 1992, and MS and Ph.D. degrees in control theory and its applications in July 1996, all from Tsinghua University, Beijing, China. He is currently a Professor and Associate Director of the Center for Intelligent and Networked Systems (CFINS) http://cfins.au.tsinghua.edu.cn, Department of Automation, Tsinghua University. He was a Visiting Scholar at Carnegie Mellon University (worked with Prof. Bruce Krogh), Pittsburgh, PA, and Harvard University, Cambridge, MA, in 2000 and 2002, respectively. He was a Visiting Professor at Cornell University, Ithaca, NY, in 2006. His current research focuses on the modeling, control and optimization of complex networked systems. He has published more than 80 research papers in peer-reviewed journals and conferences. He is a recipient of the 4th HO PAN QING YI best paper award in DEDS field in the year 2000, the 9th Guan Zhao-Zhi Award best paper award
in the year 2003 and the 2005 UTRC Outstanding Achievement Award. Dr. Zhao is an associate editor for the Journal of Optimization Theory and Applications, an associate editor for the IEEE Transactions on Automation Science and Engineering, an associate editor for the joint conference CDC-ECC’05 and International Program.