Tuesday 12 December 2023

Semi-Tensor Product of Matrices and Its Applications

Workshop at the 62nd IEEE Conference on Decision and Control

In the past decade the semi-tensor product (STP) of matrices has been the subject of extensive research and the theory of STP has been successfully applied to modelling and control of Boolean (control) networks (BNs, BCNs), evolutionary games, cross-dimensional control systems, just to cite a few. This workshop aims to provide a tutorial introduction to STP and its applications. The BN, introduced by Stuart Kauffman in 1969, is an effective model for gene regulatory networks, as well as networks in some other areas. The use of STP to derive algebraic representations of BNs and BCNs will first be illustrated. Then several recent development about control problems BCNs will be presented, including reconstruction, optimal control, observer design, fault detection, control of probabilistic BCNs, observability, synthesis based on state-feedback control, etc. The application of STP to finite games, such as potential games, networked games, etc., will also be discussed. STP-based cross-dimensional Euclidian spaces and dimension-varying dynamical systems over such spaces will be discussed. Applications of STP to engineering problems, such as mixed energy vehicles and power systems, will be presented by the end.

Expected Outcomes

1. To provide the audience with the basics and some advanced results on STP.
2. To illustrate the applications of STP to Boolean networks, as well as to the solutions to a number of control problems for BNs/BCNs.
3. To introduce the applications of STP to evolutionary games and cross-dimensional dynamic systems.
4. To present some engineering areas of applications of STP, including mixed energy vehicles and power systems.

Expected Attendance

Anyone who is interested in acquiring powerful mathematical tools to formalize and solve control problems in logical and finite-state systems, particularly young scholars who are interested in STP and its recent developments in the control community.

Daizhan Cheng graduated from Tsinghua Univ., received his master degree from Graduate School, CAS and Ph.D. degree from Washington Univ. St. Louis, USA. Since 1990 he has been a Professor with AMSS, CAS China. Fellow of IEEE (2006-), Fellow of IFAC (2008-). He is an author/co-author of 18 books and over 300 journal papers. He is the first recipient of second class prize of the National Natural Sciences Award of China twice in 2008 and 2014, and the first recipient of the Automatica 2008-2010 Theory/Methodology Best Paper Prize in 2011.

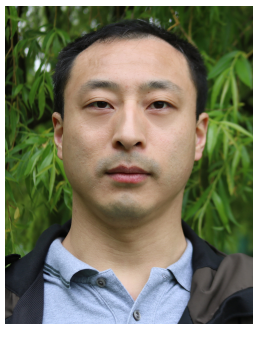
Elena Valcher has been a Professor of Control Theory at the University of Padova since 2005. Her current research interests include social networks, Boolean control networks, multi-agent systems, consensus. Author of approximately 90 journal papers, 18 book chapters, 110 conference papers and 3 textbooks. IEEE CSS President in 2015, currently EUCA Vice President and a member of the IFAC Technical Board (since 2017). IEEE Fellow (2012-), IEEE CSS Distinguished Member (2011) and IFAC Fellow (2022-). Founding Editor in Chief of the IEEE Control Systems Letters (2017-). Program Chair of the 2012 IEEE CDC, and co-General Chair of the 2022 IEEE CDC.

Xiaohua Xia lectures in the Electrical, Electronic and Computer Engineering Department, University of Pretoria, South Africa, and directs the Centre of New Energy Systems. His research interests are nonlinear control, complexity, industrial energy systems and building energy systems. He is an IEEE fellow and an NRF A-rated scientist, a fellow of the South African Academy of Engineering, and a member of the Academy of Science of South Africa. He is a registered professional engineering by the Engineering Council of South Africa, and a certified measurement and verification professional by the American Association of Energy Engineers.

Tielong Shen is a Full Professor in control engineering at Sophia University, Tokyo, Japan. He received his PhD degree in Mechanical Engineering from Sophia University 1992, and joined Sophia University in April 1992. His research interests include control theory and applications in automotive powertrain systems, power systems, and mechanical systems. Dr. Shen has authored/co-authored 11 books in Japanese, English and Chinese, respectively, and has published more than 170 journal papers. He has served SICE, TCCT of CAA, IFAC and IEEE as Chair/vice-chair including General Chair of SICE&CCC2015, IPC Chair of IFAC AAC2016, General Chair of SICE 2021, etc.

Ping Zhang received the B.Eng. degree from Huazhong University of Science and Technology and the M.Eng. and Ph.D. degrees in Control Theory and Control Engineering from Tsinghua University. She worked at the University of Duisburg-Essen and collected industrial experience at the BASF SE in Germany. Since November 2013, she has been a professor, holding the Chair for Automatic Control at the Rheinland-Pfaelzische Technische Universitaet Kaiserslautern-Landau (i.e. the former Technische Universitaet Kaiserslautern) in Germany. Her research interests are Boolean control networks, cyber security of control systems, fault diagnosis, discrete-event systems, building energy efficiency and various industrial applications. She is an author/co-author of 44 journal papers, 113 conference papers and 2 US/European patents.

Carmen Del Vecchio is Associate Professor in Automatic Control Engineering at University of Sannio, Benevento Italy. Her current research interests include model and control of logical systems, control methods applied to biological systems and manufacturing processes. IEEE Senior member (2021,-). Editor of the International Journal of Robust and Nonlinear Control, Wiley. Member of the IEEE Control System Society Conference Editorial Board and Technical Conference Editorial Board. Organizer of the European Control Conference pre-workshop on "Modeling and Control of Boolean Dynamical Systems" (2021) and the pre-conference workshop “Boolean Networks: Realization, Control, and Learning "at the 'Society of Instrument and Control Engineers (SICE)' Conference " (2021). Author of 70 papers and a book chapter.



Kuize Zhang is currently a lecturer at University of Surrey, UK. He received his Bachelor degree in Mathematics and Ph.D. degree in Control Science from Harbin Engineering University, China, in 2009 and 2014, respectively. His current research interests include Boolean control networks and discrete-event systems (finite automata, Petri nets, weighted automata over monoids). IEEE Senior Member since 2017. Alexander von Humboldt Fellow at Technical University of Berlin from 2020 to 2022. Held postdoc positions at Technical University of Munich and KTH Royal Institute of Technology. Has published 2 monographs (the one in Springer Nature, 2022 and the other in Foundations and Trends in Systems and Control, 2023-).

Jun-e Feng received her Ph.D. degree from Shandong University in Operational Research and Cybernetics from Shandong University, Jinan, China, in 2003. She is currently a Professor of the School of Mathematics at Shandong University, Jinan, China. She was a Postdoctoral Research Associate at MIT, USA, from 2006 to 2007, and a visiting scholar at the University of Hong Kong, Hong Kong, China, in 2008, 2009 and 2013. She has been member of IEEE CSS Conference Editorial Board since 2008. Her research interests include fuzzy systems, Boolean networks, and robust control, etc.

Jiandong Zhu received the Ph.D. degree in Operational Research and Cybernetics from Shandong University, Jinan, China, in 2002. Currently, he is a Professor of the School of Mathematical Sciences, Nanjing Normal University. He was a Postdoctoral Research Associate of Southeast University, Nanjing, China, from 2002 to 2004, a Visiting Academic in RMIT University, Melbourne, Australia, from 2010 to 2011, and a Visiting Scholar in University of Texas at San Antonio, USA, from 2016 to 2017. His current research interests include Boolean control networks, high-dimensional Kuramoto model and stability of nonlinear systems.

Yuhu Wu received his Ph.D. degree in mathematics from the Harbin Institute of Technology, Harbin, China, in 2012. Since 2012, he has been an Assistant Professor with Harbin University of Science and Technology, Harbin, China. He held a Postdoctoral Research position at Sophia University, Tokyo, Japan, from 2012 to 2015. In 2015, he joined Dalian University of Technology, Dalian, China, where he is currently a Professor. His research interests are Boolean Networks, game-theoretic control, and applications of control to automotive power train systems, and unmanned aerial vehicles.

Bing Zhu received the B.S. and Ph.D. degrees from Beihang University, Beijing, China, in 2007 and 2013, respectively. From 2013 to 2015, he was a Postdoctoral Fellow at the University of Pretoria, Pretoria, South Africa, supported by Vice-Chancellor Postdoctoral Fellowship. From 2015 to 2016, he was a Research Fellow at Nanyang Technological University, Singapore. In 2016, he joined Beihang University, as an Associate Professor. His research interests include model predictive control, smart sensing for UAV and UGV, and demand-side management for new energy systems. Dr. Zhu is an Associate Editor for Acta Automatica Sinica.