Guest Editorial: Cyber Physical Power Systems: Advanced Intelligent Technologies and Applications

Introduction
With the increased adoption of information and communication technologies (ICTs) and cyber and internet technologies, power systems are rapidly evolving into Cyber-Physical Power Systems (CPPS). CPPS are emerging technologies, with growing significant academic, industrial and societal impacts. Research into CPPS needs deep integration of smart electric power grid and new information systems, and consideration must be paid to the tight coupling between cyber, networking, communication and physical systems.

To this end, the interdependency of the power system and its associated cyber properties should be investigated. Advanced intelligent technologies must be developed to deal with frontier challenges arising from multiple energy resources, multiple timescales, the presence of uncertainty, the existence of reliability concerns and the security issues related to modernised power systems. It is expected that these intelligent technologies can improve power system performance in terms of security, efficiency, reliability and, make a strong economic impact. Seven papers were accepted for this Special Issue and brief introductions of them are provided below.

‘Developing correlation indices to identify coordinated cyber-attacks on power grids’, by Christian Moya and Jiankang Wang, studies coordinated cyber-attacks from the correlation indices on static control applications. The proposed indices improve attack identification, e.g., measurement attacks. Compared with existing approaches, the proposed method is deductive and able to detect sophisticated attacks without simulating a large number of attack events. A case study on the New England 39 bus system demonstrates the effectiveness of this method.

‘Electromagnetic torque analysis-based method for performance evaluation and optimisation of closed-loop CPS regarding small signal stability’, by Yibiao Sheng, Tao Lin, Rusi Chen, et al. presents a new method to explore the influence of wide-area damping control parameters and time delays for cyber-physical power system from a small signal stability viewpoint. An electromagnetic torque analysis (ETA) method is established to facilitate this stability study. The authors analyse the effectiveness and advantages of the proposed method using a two-area four-machine system.

‘Market-based generator cost functions for power system test cases’, by Venkat Durvasula and Timothy M. Hansen proposes a novel method to design generator cost functions to emulate existing market costs for power systems test cases. This paper classifies real market generator offers from an independent system operator organised electricity market into generator types. By using the new market-based generator cost functions, power system simulation studies will better represent actual economic impacts.

‘Predictive control model to manage power flow on a hybrid wind-photovoltaic and diesel microgeneration power plant with additional storage capacity’ by António José Arsenio dos Santos Costa, Duarte Valério and Paulo José da Costa Branco is aimed at using model predictive control (MPC) approach for management of the power flow in a hybrid microgeneration power plant with additional storage capacity. The objectives of MPC are to maximise the use of power from renewable resources and to maximise the duration of lithium ion batteries. MPC is proven to be a suitable strategy for management of power flow dispatch on hybrid power generation plants with renewable resources.

‘Swarm-based automation of electrical power distribution and transmission system support’, by Stefan Dähling, Sonja Kolen, and Antonello Monti presents SwarmGrid-X, an agent-based control concept that considers the structure, demands and capabilities of components in the distribution system and the power requirements of the transmission system at the point of common coupling. The cooperative nature of SwarmGrid-X transforms the distribution system into a Cyber-Physical Power System. This paper also explains how SwarmGrid-X enables cyber-physical interactions of components to automate electrical power distribution and support the transmission system.

‘Game theory-based optimal reloading control of wind turbines under scalable structures of wind farm’ by Jianliang Zhang, Yujun Li, Zhao Xu, et al. addresses the problem of how to harvest as much kinetic energy as possible during reloading control of variable speed wind turbines (VSWTs) by distributively adjusting rotor speeds under scalable wind farm topology. A game theory-based distributed control framework is investigated to enable the optimal rotor speed setting of VSWTs such that maximal kinetic energy can be stored in rotating masses of VSWTs for further system support, and meanwhile, the power dispatch objective for VSWTs can be fulfilled. Consequently, all of VSWTs within wind farm cooperatively achieve the objective of both system power balance and maximal kinetic energy harvesting.

‘Forecasting of commodities prices using a multi-factor PDE model and Kalman Filtering’, by Gerasimos Rigatos, Pierluigi Siano, Taniya Ghosh, et al. presents a method for forecasting commodities prices using Schwartz PDE and Kalman Filtering. The method is applicable to both the single-factor and the multi-factor Schwartz PDE. By redesigning the Kalman Filter as a m-step ahead predictor it becomes possible to obtain accurate estimates of the future commodities’ price. The proposed method can contribute to maximising profits in commodities trading, including also the trading of electric power.

Conclusion
The papers selected for this Special Issue present a large diversity of Cyber-Physical Power Systems (CPPS) that involve cyber, networking, communication and physical systems, where the interdependency of the power system and its associated cyber properties have been investigated. These papers have successfully demonstrated some of the notable approaches of cyber, stability, control, optimisation and modelling to meet the emerging challenges of CPPS.
Guest Editor Biographies

Xia Chen (M’13-SM’18) received the B.S. degree in power system and its automaton from Wuhan University of Technology, China, in 2006, and the M.S. and Ph.D. degrees in electrical engineering from Huazhong University of Science and Technology (HUST), China, in 2008 and 2012, respectively. She was a Post-Doctoral Research Fellow with the University of Hong Kong, from 2012 to 2015. In 2015 she joined the HUST and now she is an associate professor with the School of Electrical and Electronic Engineering, HUST. Her research interests include distributed control technology in microgrid, renewable energy integration technologies, and new smart grid device. She authored and coauthored over 30 peer-reviewed journal and conference papers. She served as the Technical Programme Committee Co-chair of IET Renewable Power Generation 2017 and IEEE PES China Chapter Secretary from 2017 to 2018. She was a recipient of the IEEE PES China Outstanding Young Volunteer Award. Currently, she is an academic editor for Chinese Society for Electrical Engineering (CSEE) Journal of Power and Energy System.

Zhen Ni is currently an Assistant Professor in Department of Electrical Engineering and Computer Science (EECS), South Dakota State University (SDSU), Brookings, SD. He received his Ph.D. degree from the Department of Electrical, Computer and Biomedical Engineering, University of Rhode Island (URI), Kingston, RI, in 2015. He received B.S in Department of Control Science and Engineering (currently renamed as College of Automation), Huazhong University of Science and Technology (HUST), Wuhan, China, in 2010.

His research mainly includes Computational Intelligence, Adaptive Control, and Cyber-Physical Systems. He has authored and co-authored for over 70 peer-reviewed research papers, including one Publication Spotlight Paper in IEEE Computational Intelligence Magazine (2013) and one Most Cited Neurocomputing Articles in Neurocomputing (2015). He is actively involved in various professional services and activities in the society, including the General Chair of IEEE computational intelligence society winter school (2016). He is an Associate Editor for IEEE Computational Intelligence Magazine (2018-) and a Guest Editor for IET Cyber-Physical Systems: Theory & Applications (2017-2018).

Yew-Soon Ong (M’99-SM’12-F’18) received the Ph.D. degree in artificial intelligence in complex design from the University of Southampton, UK, in 2003. He is currently a Professor at the School of Computer Science and Engineering, Nanyang Technological University (NTU), Singapore, where he is also Director of the Data Science and Artificial Intelligence Research Center and Singtel-NTU Cognitive & Artificial Intelligence Corporate Laboratory. His research interest in artificial intelligence spans across memetic computing, optimisation intelligence, and machine learning. Dr. Ong is the founding Editor-in-Chief of the IEEE Transactions on Emerging Topics in Computational Intelligence, founding Technical Editor of Memetic Computing and associate editor of the IEEE Transactions on Evolutionary Computation, the IEEE Transactions on Neural Networks & Learning Systems, the IEEE Transactions on Big Data, and others. He has received several IEEE outstanding paper awards and listed as a Thomson Reuters highly cited researcher and among the World’s Most Influential Scientific Minds.

Miao Yu received the B.S. degree in Automation from College of Electrical Engineering, Zhejiang University, China, in 2007, and the Ph.D. degree in Control Science and Engineering from College of Electrical Engineering, Zhejiang University, China, in 2012. From 2013 to 2015, he was with Aalto University, Finland, as a Postdoctoral Researcher. Since 2016, he has been with the College of Electrical Engineering, Zhejiang University, where he is now an Associate Professor. His current research interests include stability analysis and control strategies in microgrid and renewable power generation. He has authored or coauthored more than 50 technical papers in international journals and conferences. He has served on the technical program committee for several academic conferences.

Cesare Alippi received the degree in electronic engineering cum laude in 1990 and the PhD in 1995 from Politecnico di Milano, Italy. Currently, he is a Professor with the Politecnico di Milano, Milano, Italy and Università della Svizzera italiana, Lugano, Switzerland. Currently, he is a visiting professor at the University of Kobe, Japan, and the University of Guangzhou, China. He has been a visiting researcher at UCL (UK), MIT (USA), ESPCI (F), CASIA (RC), A*STAR (SIN).

Alippi is an IEEE Fellow, Member of the Administrative Committee of the IEEE Computational Intelligence Society, Board of Governors member of the International Neural Network Society, Board of Directors member of the European Neural Network Society, Past Vice-President education of the IEEE Computational Intelligence Society, past associate editor of the IEEE Transactions on Emerging topics in computational intelligence, the IEEE Computational Intelligence Magazine, the IEEE-Transactions on Instrumentation and Measurements, the IEEE-Transactions on Neural Networks. In 2018 he received IEEE CIS Outstanding Computational Intelligence Magazine Award, the 2016 Gabor award from the International Neural Networks Society and the IEEE Computational Intelligence Society Outstanding Transactions on Neural Networks and Learning Systems Paper Award; in 2013 the IBM Faculty award; in 2004 the IEEE Instrumentation and Measurement Society Young Engineer Award. Current research activity addresses adaptation and learning in non-stationary environments, graphs learning and Intelligence for embedded and cyber-physical systems. He holds 8 patents, has published one
monograph book, 7 edited books and about 200 papers in international journals and conference proceedings.

Jian Li received his BSc, MSc, and Ph.D degrees in Detection Technology and Automatic Engineering from University of Electronic Science and Technology of China (UESTC) in 2007, 2010, and 2014, respectively. In 2011–2013, he was awarded a scholarship by China Scholarship Council (CSC) to visit the Telerobotic and Biorobotic Systems Group of the University of Alberta as a visiting doctoral student supervised by Dr. Mahdi Tavakoli. He is currently an associate professor at UESTC. His current research and academic interests include power system analysis and control, renewable energy integration, and Cyber-Physical Systems. He has authored and co-authored for over 40 peer-reviewed research papers.