# Plenary sessions

**Plenary talk I: "The Origin and Goal of Future in CPSS: Industries 4.0 and Industries 5.0"**

**Fei-Yue Wang**, Chinese Academy of Sciences - China

*Monday, October 7th, 09:30-10:30, Plenay Room*

**Abstract**: With the rapid development of Artificial Intelligence (AI), big data, and IoT technologies, the industrial systems are evolving fast into a class of Cyber-Physical-Social Systems (CPSS), which provide a wide range of challenges and opportunities for enterprise management. In this presentation, I will first outline the trend of intelligence, and discuss the evolution from Industrie 4.0 to Industries 5.0. The core of Industrie 4.0 is "ICT + CPS", and it is previously interpreted as "Information and Communication Technology + Cyber-Physical Systems". However, in the era of Industries 5.0, its interpretation has changed to "Intelligence and Connectivity Technology + Cyber-Physical-Social". Then, I will introduce the Parallel Industrial Systems (PIS) based on the ACP approach within the framework of Industries 5.0. The basic ideas of PIS are 1) modeling and representing real industrial systems using artificial industrial systems; 2) analyzing and evaluating industrial situations by computational experiments; and 3) controlling and managing industrial systems by parallel execution through interactions of real and artificial industrial systems. The ACP based PIS provides a platform to generate big data from small data, and then characterize big data to small intelligence for specific tasks via various AI methods, which enables seamless integration of AI techniques into industrial operations. Finally, I will summarize our real-world practices and case studies of PIS over the last two decades in China.

**Fei-Yue Wang** received his Ph.D. in Computer and Systems Engineering from Rensselaer Polytechnic Institute, Troy, New York in 1990. He joined the University of Arizona in 1990 and became a Professor and Director of the Robotics and Automation Lab (RAL) and Program in Advanced Research for Complex Systems (PARCS). In 1999, he founded the Intelligent Control and Systems Engineering Center at the Institute of Automation, Chinese Academy of Sciences (CAS), Beijing, China, under the support of the Outstanding Overseas Chinese Talents Program from the State Planning Council and "100Talent Program" from CAS, and in 2002, was appointed as the Director of the Key Lab of Complex Systems and Intelligence Science, CAS. From 2006 to 2010, he was Vice President for Research, Education, and Academic Exchanges at the Institute of Automation, CAS. In 2011, he became the State Specially Appointed Expert and the Director of the State Key Laboratory for Management and Control of Complex Systems. Dr. Wang's current research focuses on methods and applications for parallel systems, social computing, parallel intelligence and knowledge automation. He was the Founding Editor-in-Chief of the International Journal of Intelligent Control and Systems (1995-2000), Founding EiC of IEEE ITS Magazine (2006-2007), EiC of IEEE Intelligent Systems (2009-2012), and EiC of IEEE Transactions on ITS (2009-2016). Currently he is EiC of IEEE Transactions on Computational Social Systems, Founding EiC of IEEE/CAA Journal of Automatica Sinica, and Chinese Journal of Command and Control. Since 1997, he has served as General or Program Chair of more than 20 IEEE, INFORMS, ACM, and ASME conferences. He was the President of IEEE ITS Society (2005-2007), Chinese Association for Science and Technology (CAST, USA) in 2005, the American Zhu Kezhen Education Foundation (2007-2008), the Vice President of the ACM China Council (2010-2011), and the Vice President and Secretary General of Chinese Association of Automation (CAA, 2008-2018). Since 2019, he has been the President of CAA Supervision Council. Dr. Wang has been elected as Fellow of IEEE, INCOSE, IFAC, ASME, and AAAS. In 2007, he received the National Prize in Natural Sciences of China and was awarded the Outstanding Scientist by ACM for his research contributions in intelligent control and social computing. He received IEEE ITS Outstanding Application and Research Awards in 2009, 2011 and 2015, and IEEE SMC Norbert Wiener Award in 2014.

**Plenary talk II: "Formal Methods for Complex Workflow Management in Industry 4.0"**

**Spyros Reveliotis**, School of Industrial and Systems Engineering at Georgia Tech, USA

*Tuesday, October 8th, 09:00-10:00, Plenary Room*

**Abstract**: Some primary strategic objectives for modern corporations are the support of ever increasing levels of customization for the offered products and services, with a simultaneous reduction of the production lead times and the operational costs. The current advent of Industry 4.0 seeks to address these requirements by taking advantage of the extensive capabilities of sensing, communication, and computation that are provided by the modern information technology and the proliferation of this technology in the current industrial settings. These capabilities enable a very comprehensive and detailed view of the real-time status of the underlying operations, and the dissemination of the corresponding information to any stakeholder of this production process. They also facilitate, in principle, the effective control of this production process through well-informed and timely decisions. However, in reality, this decision making process can be challenged by extensive levels of conceptual and computational complexity that results from the extensive levels of flexibility, concurrency and automation (or even autonomy) that are aspired for the targeted operations. This talk will overview the results of a research program that has sought to address the aforementioned challenges through the formal abstraction of the operations that take place in the considered environments into a resource allocation system (RAS), and the employment of this abstraction for the formulation and the systematic investigation of a number of optimal control problems that will guarantee the integrity and the efficiency of these operations. Besides providing the necessary qualitative insights regarding the nature of optimality in the underlying decision-making process and the factors that determine this optimality, the availability of the aforementioned RAS models and formulations also enable a systematic and very effective management of the inherent trade-off between the computational tractability of the decision-making process involved and the operational efficiency of the derived solutions. Finally, an additional important feature of the presented models and methods is that they are applicable not only in the context of the industrial processes that are typically targeted by Industry 4.0, but also in any other application context that concerns the management of complex sequential resource allocation. Some characteristic examples of such application contexts are the workflows that take place in modern health care systems; the internet-enabled workflow concerning the "backend" operations taking place in certain service areas like logistics, banking, and insurance claiming; and the traffic coordination in (automated) transport systems where the traffic evolves in a constricted medium represented by the links of a "guidepath network".

**Spyros Reveliotis** received the Diploma degree in electrical engineering from the National Technical University of Athens, Greece, in 1989, the M.Sc. degree in computer systems engineering from Northeastern University in Boston, 1992, and the Ph.D. degree in industrial engineering from the University of Illinois at Urbana-Champaign in 1996. Since 1996 he has been with the School of Industrial and Systems Engineering at the Georgia Institute of Technology, in Atlanta, GA, where currently he serves at the rank of Professor. His main research interests are in discrete-event systems theory and its applications. Dr. Reveliotis is an IEEE Fellow, and a member of INFORMS and IISE. He has served on the editorial boards of many journals and conferences in his areas of interest. Currently, he serves as a Senior Editor for the IEEE Transactions on Automation Science and Engineering, an Associate Editor for the Journal of Discrete Event Dynamic Systems, and the Editor-in-Chief of the Editorial Board at the IEEE Conference on Automation Science and Engineering (CASE). He has also served as the Program Chair at the 2009 IEEE CASE Conference, and the General Co-Chair of the 2014 edition of the same conference, while from 2016 to 2018 he was a Governor of the American Automatic Control Council (AACC) representing the INFORMS Applied Probability Society. Finally, he and his students have been the recipients of a number of awards, with the most recent one being the 2014 Best Paper Award of the IEEE Transactions on Automation Science and Engineering.

**Plenary talk III: "Hydrogen society for energy transition"**

**Zofia Lukszo**, Delft University of Technology, the Netherlands. Faculty of Technology, Policy and Management.

*Wednesday, October 9th, 11:30-12:30, Plenary Room*

**Abstract**: In the transition toward a sustainable energy system, green hydrogen as a carrier of solar and wind energy, may play many important roles. Green hydrogen can be produced from green electricity by electrolysis, from biogas by steam reforming or from biomass through gasification. Like natural gas, it can be transported by ships and trucks or via pipelines. Hydrogen is clean and safe energy carrier that can be used as a fuel in transportation (fuel for Fuel Cell Electric Vehicles FCEV), for home heating and electricity production, as well as a feedstock for industry. In the presentation the role of hydrogen society for energy transition will be addressed showing that hydrogen can not only contribute to the decarbonization of the energy sector, but also of the process industry, mobility and transport. In particular a community microgrid in a smart city with renewable generation, storage, and Fuel Cell Electric Vehicles (FCEV) that are used when renewable sources are scarce will be discussed. In such a system the traditional roles of consumers and suppliers are changing: households supply the surplus energy from their panels to the grid and become so-called prosumers as they use and produce energy. This is also leading to the emergence of new business models and new services, such as those provided by aggregators mediating on behalf of groups of households or companies between flexible supply and demand of electricity.

**Zofia Lukszo** is full professor at the Delft University of Technology, the Netherlands. She heads the Energy and Industry Group at the Faculty on Technology, Policy and Management. Her research concentrates on a wide range of problems in the way complex energy systems are functioning and can be (re-)shaped for the sustainable future. Shaping smart grids, which require additional flexibility from the users in interaction with dispatchable power plants, storage and interconnections, forms a main pillar in her research. As a senior IEEE Member she contributed to many international workshops and conferences. She has over 150 refereed scientific publications and book contributions. Research interests:

- Modelling and optimization of energy systems
- Electric mobility
- Agent-based modelling.