Guest Editorial Networking, Sensing, and Control for Networked Control Systems: Architectures, Algorithms, and Applications

THE accelerated integration and convergence of communications, computing, and control over the last decade has inspired researchers and practitioners from a variety of disciplines to become interested in the emerging field of networked control systems (NCS). In general, an NCS consists of sensors, actuators, and controllers whose operations are distributed at different geographical locations and coordinated through information exchanged over communication networks. Some typical characteristics of those systems are reflected in their asynchronous operations, diversified functions, and complicated organizational structures. The widespread applications of the Internet have been one of the major driving forces for research and development of NCS. More recently, the emergence of pervasive communication and computing has significantly intensified the effort of building such systems for control and management of various network-centric complex systems that become more and more popular in process automation, computer-integrated manufacturing, business operations, as well as public administration.

Control over a communication network is not a new concept in automation. From teleoperation for space and hazardous environments to process regulation with distributed control systems, control systems with communications have already been developed and utilized in applications of real-world problems for almost 30 years [1]. There are many factors that distinguish the current NCS and previous control with communications. Two of them are the most significant: 1) in the previous control with communications, the network is specialized and dedicated for the timeliness of information exchange and stability of process operation, while in the current NCS the network is general-purpose and public for various irrelevant yet concurrent applications, and thus real-time communication and stable operation are no longer ensured and 2) the functionality of the NCS from the previous to current has been diversified tremendously, from pure control to a variety of control and management or administrative functions, ranging from resource allocation, event scheduling, to task organization, etc., involving concept and methods from control and communication engineering, operations research, computer science, and management science.

Demands on diversity, complexity, and real-time performance for networked operations have brought new technological challenges to NCS. Today, many fundamental questions regarding the stability of interconnected dynamical systems, the effects of communication on the performance of control systems, etc., remain open and to be answered. Even from the perspective of control aspect alone, we need to think about what the new direction for research and application in this age of connected world would be. One potential approach is to extend the concept of "programming on demand" with agent programming to "control on demand" with agent-based control (so-called ABC) [2]. In other words, can we liberate control algorithms that are fixed to controlled plants to control agents that are free and mobile in a connected world? Once this is accomplished, various innovative methods based on connectivity can be employed for control and management, e.g., using "local simple, remote complex" principle to design low-cost yet high-performance and intelligent NCS that require less computing power, small memory space, and few upgrades [3], [4]. Indeed, there are many new, exciting, and challenging ideas and problems in the field of NCS.

This special issue is dedicated to address some of the questions and problems discussed above. The eight papers can be divided into three groups. The first group consists of three papers that deal with issues directly related to control over the Internet, especially fuzzy control, predicative control, and multirate control of NCS. The second group has two papers for design and evaluation of network architectures for service delivery and operation control. The third group discusses intelligent control algorithms and techniques that might have great potential for applications in NCS.

The special issue starts with the paper by Zhang, Yang, and Chai on the guaranteed cost networked control (GCNC) for T–S fuzzy systems with time delay, where the state feedback controller with GCNC using the Takagi–Sugeno (T–S) method is developed for NCS and its stability is established and validated through computer simulations. In the second paper, Liu, Xia, Rees, and Hu discuss issues in the design and stability analysis of networked predictive control systems with random delay in the feedback. After adapting the principle of predicative control to network-based control to overcome the effects of time delay, the authors establish necessary and sufficient conditions for the stability of closed-loop NCS. Yang and Yang address the architectural and procedural aspects of using multirate control in Internet-based control systems. In their paper, a two-level hierarchy with remote and local controllers is used for the Internet-based control systems where two compensators are placed in the feedback and feedforward channels, respectively.

Intelligent home systems can be significant for potential applications of NCS. Wu, Liao, and Fu investigate the protocol and architectural issues for service-oriented smart homes and

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the process of service delivery with the protocol defined by the Open Services Gateway initiative (OSGi) Alliance. Based on the multiple OSGi platforms and mobile agent technology, the authors propose a service-oriented smart home architecture for dynamical service delivery and peer-to-peer operations. In their paper on fairness and dynamic flow control, Yang, Cao, Tan, and Yi focus on the rate control problem of feedback-based sessions in the coexistence of both unicast and multirate mulitcast traffic architecture networks. A strategy called "reasonable consumption" is proposed for achieving the fairness, and a Lyapunnov approach is used for accomplishing the stable multirate control for flow congestion in multicast services.

Wu, Hu, and Xie present a new intelligent control method based on an intelligent characteristic model for a kind of complicated plant with nonlinearities and uncertainties, whose controlled output variables cannot be measured online continuously. The basic idea of their method is to utilize intelligent techniques to form the characteristic model of the controlled plant, and then to present a new design method of intelligent controller based on this characteristic model. The application result in the aluminum electrolytic process is really impressive and convincing. In their paper on distributed simulation of differential algebraic systems, Rum and Gordon investigate the optimal solution of differential algebraic equations over a network of processors using optimal sliding mode control to address the sensor and network time delays associated with communications. In a connected world, cars will be mobile offices and homes where networked control and operation will become important and central. One of the most active current research topics in intelligent vehicles is robust vehicular vision systems for driving safety and comfort. In their paper on a novel robust in-car digital image stablization, Hsu, Liang, Pu, and Lin propose a technique that can stably remove the unwanted shaking phenomena in the image sequences captured by in-car video cameras without the influence caused by moving objects in the image or intentional motion of the car. Their techique can be of important practical implication on future mobile visual systems for wireless networked applications.

Finally, as the guest editors of the special issue, we would like to express our sincere appreciation to all reviewers for their time and effort, and to the editorial assistants of this Transactions for their patience and great help.

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FEI-YUE WANG, *Guest Editor*
Department of Systems and Industrial Engineering
University of Arizona
Tucson, AZ 85721 USA

Key Laboratory of Complex Systems
and Intelligence Science
Institute of Automation
Chinese Academy of Sciences
Beijing 100864, China

DERONG LIU, *Guest Editor*
Institute of Electrical Engineering
Yanshan University
Qinhuangdao 066004, China

Department of Electrical and Computer Engineering
University of Illinois
Chicago, IL 60607 USA

SIMON X. YANG, *Guest Editor*
School of Engineering
University of Guelph
Guelph, ON N1G 2W1, Canada

LI LI, *Guest Editor*
Department of Automation
Tsinghua University
Beijing 100084, China

Fei-Yue Wang (S'87–M'89–SM'94–F'03) received the Ph.D. degree in electrical, computer, and systems engineering from Rensselaer Polytechnic Institute, Troy, NY, in 1990.

He is currently a Professor of systems and industrial engineering and the Director of Program for Advanced Research in Complex Systems. In 1999, he founded the Intelligent Control and Systems Engineering Center at the Institute of Automation, Chinese Academy of Sciences, Beijing, under the support of the Outstanding Overseas Chinese Talents Program. Since 2002, he has been the Director of the Key Laboratory of Complex Systems and Intelligence Science, Chinese Academy of Sciences.

Dr. Wang is a Fellow of International Council of Systems Engineering, an elected member of the IEEE SMC Board of Governors and AdCom of the IEEE Nanotechnology Council, President of the IEEE Intelligent Transportation Systems Society, and the 2005 President of the Chinese Association for Science and Technology, USA. He is also the Chair of the Technical Committee on System Complexity of the Chinese Association of Automation, Vice-President of the Chinese Transportation and Information Systems Engineering Society, Vice-President and one of the major contributors of the American Zhu Kezhen Education Foundation, and a member of the Boards of Directors of five companies in information technology and automation. He is also a member of Sigma Xi, ACM, ASME, and ASEE.

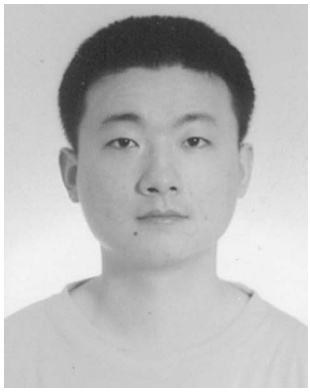
Derong Liu (S'91–M'94–SM'96–F'05) received the Ph.D. degree in electrical engineering from the University of Notre Dame, Notre Dame, IN, in 1994.

He joined the University of Illinois at Chicago in 1999, where he is currently a Full Professor of electrical and computer engineering and of computer science. Since 2005, he has been the Director of Graduate Studies in the Department of Electrical and Computer Engineering, University of Illinois at Chicago. He has published six books.

Dr. Liu received the Michael J. Birck Fellowship from the University of Notre Dame (1990), the Harvey N. Davis Distinguished Teaching Award from the Stevens Institute of Technology (1997), the Faculty Early Career Development (CAREER) Award from the National Science Foundation (1999), and the University Scholar Award from the University of Illinois (2006–2009).

Simon X. Yang (M'99–SM'05) received the Ph.D. degree in electrical and computer engineering from the University of Alberta, Edmonton, AB, Canada, in 1999.

He joined the School of Engineering, University of Guelph, Guelph, ON, Canada as an Assistant Professor of systems and computer engineering in August 1999. He was awarded tenure at the University of Guelph in 2002. Currently he is an Associate Professor and the Director of the Advanced Robotics and Intelligent Systems Laboratory at the University of Guelph in Canada.



Li Li (S'05–M'06) is currently an Assistant Professor in the Department of Automation, Tsinghua University, Beijing, China. His current research fields include intelligent optimization, intelligent control and sensory systems, intelligent transportation systems, and intelligent vehicles.