Guest Editorial Advances in Theories and Industrial Applications of Networked Control Systems

THE concept of networked control systems (NCSs) has been around us for quite some time, even before the early years of the 21st century. Until then, a considerable number of special issues on NCSs had already appeared in a number of journals devoted to automation, inspired by the advances in both academic research and industrial applications. During the past five years however, we have witnessed a further remarkable rapid development of computing, communication and control technologies, particularly with respect to the relative maturity of network media such as Ethernet, Internet, and wireless networks. These technology evolvements continuously spur the proliferation of NCSs, ranging from the classical NCSs to distributed NCSs, networked multi-agent systems, etc. Moreover, the growing needs in recent years for the realization of larger scale and, therefore, more complex control systems and control tasks also motivate more wide-ranging and in-depth investigations on NCSs. Both classical and emerging issues, such as control and estimation over a network, fault detection, diagnosis and tolerant control over a network, control of networked Cyber Physical Systems, distributed sensor observations, coordination and cooperation of networked multi-agent systems, clock synchronization, network security, etc., necessitate transdisciplinary studies from communities of control, communication and computation so as to enable wider and more successful applications.

The purpose of this Special Section is to brief the industrial informatics audience on the advances in theories and industrial applications of NCSs, especially on those advances that have made their way into the literature since the previous special issues/sections, most of which came forth earlier than five years ago. This Special Section consists of 17 papers which can be divided into two groups; the first one mainly focusing on the issues in classical NCSs, and the second one addressing, broadly speaking, the distributed NCSs, cooperation and coordination of networked multi-agent systems.

The first group starts with a survey paper by three of the Guest Editors. This paper aims to provide a comprehensive overview of the studies on network-induced imperfections which can be treated as constraints in the analysis and the design of the underlying systems when inserting a network into the control loop. The next three papers in this group are concerned with control design for classical NCSs, emphasizing different network-induced constraints. In the paper by M. Cea Garrido and G. Goodwin, the limited transmission bit rate constraint which can be seen as the source of most other network-induced imperfections is reconsidered. A novel nonlinear decode model predictive controller is designed for the underlying system. In the paper by Y. Xia and J. Yan *et al.*, the constraint of data quantization is reinvestigated, and the scenario of a system with both quantized input and quantized measurements is considered. In the paper by H. Zhang and Y. Shi, the optimal tracking control problem is studied for a class of networked nonlinear systems, taking into account the constraints of time delay and packet loss.

Two papers oriented towards network-based industrial processes control systems are covered in this group. In the paper by T. Chai and L. Zhao, a model predictive controller allowing for random packet losses is designed to realize automatic set point tracking according to the desired economic objective. In the paper by P. Zhang and S. Ding *et al.*, an integrated framework of fault detection and tolerant control over wireless network is designed by setting up a multilayer system structure, consisting of distributed observers at a higher level and local residual generators at a lower level.

Another two papers in the group focus on the control of networked cyber-physical systems. The paper by J. Yao and X. Liu *et al.*, addresses a reliable networked control paradigm for a class of cyber-physical systems. The paradigm is formed by a high assurance, high-performance controller, and a switching logic governing the transitions between the two designed controllers when faults are detected. The paper by X. Cao and P. Cheng is concerned with the codesign of communication protocol and controller for networked cyber-physical systems by considering two network-induced constraints, delays and packet losses.

The last paper, by J. Aweya, included in the group seeks for solutions for differential timing transfer and recovery over packet networks, which is the important basis of configuring a networked control system in terms of clock synchronization between network nodes.

The second group starts with another survey paper by C. Cao and W. Ren, *et al.*, on the progresses in the study of distributed multi-agent coordination since 2006. The critical results in the area are categorized according to several typical topics, such as consensus, formation control, distributed optimization, distributed task assignment, distributed control and estimation, etc. The next three papers in the group are mainly concerned with the control issues of networked multi-agent systems. In the paper by D. Han and G. Chesi, the robust consensus problem is investigated for a class of multi-agent systems with uncertainties that can be described by a weighted adjacency matrix. In the paper by J. Zhan and X. Li, the flocking problem of multi-agent systems is revisited by designing model predictive controller based only on the position measurements. In the paper by X. Xiang, the coordinated paths tracking control for a team of networked nonholonomic mobile vehicles is addressed.

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The other two papers in the group are concerned with mobile sensor networks. In the paper by T. Cheng and S. Andrey, the so-called blanket coverage problem is reinvestigated by means of decentralized control of a team of mobile sensors. In the paper by M. Hamid and H. Jalal, the coverage problem of a network of mobile sensors for different targeted points is revisited. The distributed deployment strategies are proposed to increase the coverage in a network of mobile sensors with a prescribed importance for different points in the network.

Another paper in the group, by P. Panagiotis and P. Marios, considers distributed fault tolerant control. The faults can occur in the local dynamics of the subsystems, as well as in the interconnections. Linearly parameterized neural networks are used to adaptively approximate the unknown interconnections and the fault functions.

The last paper by W. Zeng and Y. Chow, addressing network security problem of distributed NCSs, is also included in the group. By adopting the co-evolutionary genetic algorithm, the tradeoff between dynamic performance and security (by certain measures) of distributed NCSs is modeled and optimized.

As the Guest Editors of the Special Section, we realize that the advances in the area of NCSs cannot be completely covered by the 17 papers we have brought together. Nevertheless, we hope the Special Section can motivate the readers to continuously challenge the research needs, either for theoretical foundations or for practical applications.

Finally, we would like to sincerely thank for the submissions by the leading researchers in the field, the contributions of the reviewers who helped the authors improve their manuscript, and thank the editorial assistants of this TRANSACTION for their great time and efforts.

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