Special Issue On Performance Analysis and Synthesis of Complex Networked Systems With Communication Scheduling

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SPECIAL ISSUE ON PERFORMANCE ANALYSIS AND SYNTHESIS OF COMPLEX NETWORKED SYSTEMS WITH COMMUNICATION SCHEDULING

PART I: FILTERING

Over the past few decades, research of complex networked systems has attracted rapidly growing interest, benefiting from their easy maintenance and installation, large flexibility and low cost. A key feature of such a complex networked system lies in that various system components/devices are mutually connected via communication cables or wireless communication medium. Numerous results on performance analysis and parameter design of complex networked systems have been reported. It is worth noting that data exchanges among various system components/devices are usually governed by suitable communication scheduling protocols with an aim to offer advantages in resource-constrained applications, such as improved communication bandwidth usages, reduced computational cost, lower sensing/actuation frequencies, and so on. As such, complex networked systems with communication scheduling find wide applications in the resource-limited execution of sensing, actuation, and decision-making in the field of cybernetics, especially in signal processing and control across industrial systems. There is no doubt that the system performance analysis and control design of these systems become much more complex and challenging than the ones already studied in non-networked scenarios due mainly to the communication induced asynchronous coupling, periodic switches, accumulated delays, as well as unknown-but-bounded disturbances. Therefore, it is of great significance to understand how to integrate advanced communication scheduling techniques with novel modeling, filtering and control methodologies in complex networked systems.

The purpose of this Special Issue is to advance the application of communication scheduling technology and methodology in complex networked systems, and further promote the research activities in filtering and control subject to communication scheduling, insecure data transmission, unreliable communication as well as communication induced phenomena. After a rigorous and careful peer-review process, 17 high-quality papers have been selected from the submissions for this Special Issue, where each paper has been reviewed by at least two reviewers. However, this Special Issue is by no means

complete. It is expected that the Special Issue will stimulate further related research and applications in this significant and timely subject.

In this Special Issue, we have divided the papers into two parts: Part I: Filtering of complex networked systems with communication scheduling; Part II: Control of complex networked systems with communication scheduling.

FILTERING OF COMPLEX NETWORKED SYSTEMS WITH COMMUNICATION SCHEDULING

Filtering or state estimation has long been a fundamental issue in the area of signal processing that has drawn much research attention. This part consists of 9 high-quality papers and starts with a survey paper "*Distributed filtering of networked dynamic systems with non-Gaussian noises over sensor networks: A survey*" by Ding *et al.*, which provides a comprehensive review of typical structures of distributed filters, representative models and analytical strategies for networked systems with various network-induced phenomena or communication scheduling in the literature. In this group, all the remaining papers have been classified into three subgroups as follows.

Performance analysis and synthesis under event-triggered scheduling

Communication scheduling can alleviate the network congestion and prolong the service life of the equipment, thereby being regarded as one of the most effective schemes to reduce resource consumption. In particular, event-triggered scheduling has gained an intensive interest in the past few years. This subgroup consists of three papers, which deal with different problems regarding event-triggered state estimation of networked nonlinear systems and multi-rate systems. For nonlinear complex networks with fading measurements and stochastic coupling strength, an event-based strategy of recursive state estimation is developed in the paper entitled "*Optimized state estimation for nonlinear dynamical networks subject to fading measurements and stochastic coupling strength: An event-triggered communication mechanism*" by Jia *et al.*, where a changeable event-triggered threshold is adopted to adjust the data transmission frequency, and a minimum upper bound of estimation error covariance dependent on admissible linearization errors, fading measurements as well as the stochastic coupling strength is obtained via the designed estimator gain. Considering discrete-time T-S fuzzy systems with time-delays and multiple missing measurements, in the paper entitled "*Non-fragile estimation for discrete-time T-S fuzzy systems with event-triggered protocol*" by Han *et al.*, a design scheme of the event-based estimator under the exponentially ultimate boundedness in the mean square is developed with the help of the Lyapunov-Krasovskii functional. In the paper entitled "*Event-based multi-objective filtering for multi-rate time-varying systems with random sensor saturation*" by Li *et al.*, a Lebesgue type filtering is designed, where the high-frequency period of the internal state of the system is nondestructively converted to the low-frequency period in order to overcome the challenge from multiple rates.

Performance analysis and synthesis under Round-Robin/stochastic scheduling

Apart from event-triggered scheduling, alternative scheduling techniques including stochastic access scheduling and Round-Robin scheduling have also been widely employed in networked systems. However, the communication burden in such a scheduling depends on the number of equipment or nodes and can be predetermined. Furthermore, when a certain sensor is investigated, the ratio of obtaining the token is the same as others under Round-Robin scheduling and is predetermined according to the given probabilities under stochastic access scheduling. This subgroup consists of three papers, dealing with the issues of fault estimation, finite-horizon filtering, and mobile robot localization, respectively. More specifically, considering nonlinear time-varying systems, the paper entitled "*Fault estimation for time-varying systems with Round-Robin protocol*" by Fu *et al.* studies a design scheme of finite-horizon H_∞ fault estimator for randomly occurring faults described by a Bernoulli distributed white sequence, where a necessary and sufficient condition on the existence of fault estimator is established with the help of H_∞ cost and an auxiliary cost. The paper entitled "*Variance-constrained H_∞ finite-horizon filtering for multi-rate time-varying networked systems based on stochastic protocols*" by Lyu *et al.* discusses a class of multi-objective and multi-rate filtering issues, where the lifting technique is utilized to overcome the challenge from multi-rates and the desired filter realizing the multiple indexes is obtained by solving recursively linear matrix inequalities. An application of stochastic communication scheduling is performed in the paper "*Mobile robot localization under stochastic communication protocol*" by Lu *et al.*, in which a robot localization is first modeled according to the physical mechanism and the gain matrices of the desired filter are then designed in term of a solution of two coupled backward recursive Riccati equations.

Performance analysis and synthesis under non-ideal communication

Compared with the utilization of communication protocols, data can be exchanged via preallocated channels with different energy requirements among equipment or subsystems. Usually, data transmission with high reliability is implemented via channels with enough energy allocation, and others via channels with low energy allocation which could lead to packet dropouts with some certain probability. In light of this consideration, the paper entitled "*Distributed resilient filtering of large-scale systems with channel scheduling*" by Xu *et al.* provides a novel design scheme of distributed filter by fusing the compensated neighboring estimation and a communication scheduling matrix, where two matrix-valued functions are derived to obtain the bounds of the covariance matrices of one-step prediction errors and the filtering errors, the effect on filtering performance from packet loss is profoundly discussed and a simulation example on wide-area power systems is exploited to check the usefulness. On the other hand, considering wireless sensor networks subject to random link failures, the paper entitled "*On hybrid consensus-based extended Kalman filtering with random link failures over sensor networks*" by Zhu *et al.* discloses the boundedness condition of error covariances for the hybrid consensus-based filtering algorithm, where a novel observability condition, called parameterized jointly uniform observability, is proposed.

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