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Editorial

New Trends in Networked Control of Complex Dynamic Systems: Theories and Applications

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In recent years, networked control systems (NCSs) have been extensively studied in both academy and industry and used in many fields, such as telerobotics, smart grids, intelligent transportation systems, and even in medical, military, and aerospace applications. NCSs offer great advantages, such as low cost, high reliability, simple installation and maintenance, and reduced weight and power requirements. In the meantime, the common shortcomings of the communication networks, such as transmission delays, packets drops and disorder, and data quantization, also appeared in the loops of the networked systems. During past decade, plenty of studies have been carried out in the literature to address the network-induced problems for given dynamic systems that are relatively simple. However, more challenging mathematical problems such as network-based control of more complex dynamics, including time delay, parameter variations, uncertainties, and nonlinearities, are still largely open and necessitate further investigations to enable wider and more successful applications. This special issue aims to provide a timely discussion on the trends and challenges of networked control of complex dynamics systems. Both theoretical and application-oriented papers are sought for, addressing the issues and mathematical techniques of network-based control, sensing, multiagent control of complex dynamic systems, and so forth.

This special issue contains fifty papers, the contents of which are summarized as follows.

"*Identification of LTI time-delay systems with missing output data using GEM algorithm*" by X. Yang and H. R. Karimi considers the parameter estimation for linear time-invariant (LTI) systems in an input-output setting with output error (OE) time-delay model structure. The problem of missing data is commonly experienced in industry due to irregular sampling, sensor failure, data deletion in data preprocessing, network transmission fault, and so forth. To deal with the identification of LTI systems with time-delay in incomplete-data problem, the generalized expectation-maximization (GEM) algorithm is adopted to estimate the model parameters and the time-delay simultaneously.

"*Guaranteed cost control for multirate networked control systems with both time-delay and packet-dropout*" by Q. Zhu et al. presents a new stabilization method for multirate NCSs. A multirate NCSs with simultaneous consideration time-delay and packet-dropout is modeled as a time-varying sampling system with time-delay. The proposed Lyapunov function deceases at each input signal updating point, which is largely ignored in prior works. Sufficient condition for the stochastic mean-square stability of the multirate NCSs is given, and the cost function value is less than a bound.

"*Fault detection for network control systems with multiple communication delays and stochastic missing measurements*" by J. Zhang et al. considers the fault detection problem for a class of network control systems (NCSs) with multiple communication delays and stochastic missing measurements.

The missing measurement phenomenon occurs in a random way and the occurrence probability for each measurement output is governed by an individual random variable. Besides, the multiple communication delay phenomenon reflects that networked control systems have different communication delays when the signals are transferred via different channels.

"*Effects of surfactants on the performance of CeO_2 humidity sensor*" by C. Wang et al. In this paper, nanosized CeO_2 powders were synthesized via hydrothermal method with different types of surfactants (polyethylene glycol (PEG), cetyl trimethyl ammonium bromide (CTAB), and sodium dodecylbenzene sulfonate (SDBS)). X-ray diffraction, Raman spectroscopy, and transmission electron microscopy were utilized to characterize the phase structures and morphologies of the products. The sample with CTAB as surfactant (CeO_2-C) has the largest specific surface area and the smallest particle size among these three samples. The humidity sensor fabricated by CeO_2-C shows higher performance than those used in the other two simples.

"*Attitude stabilization control of a quadrotor UAV by using backstepping approach*" by X. Huo et al. investigates the modeling and attitude stabilization control problems of a four-rotor vertical take-off and landing unmanned air vehicle (UAV) known as the quadrotor. The quadrotor's attitude is represented by the unit-quaternion rather than Euler angles to avoid singularity problem. Taking dynamical behavior of motors into consideration and ignoring aerodynamic effect, a nonlinear controller is developed to stabilize the attitude. The control design is accomplished by using backstepping control technique.

"*Optimal distributed controller design for nonlinear coupled dynamical networks*" by H. Zhang et al. presents the optimal distributed impulsive controller design for globally exponential synchronization of nonlinear dynamical networks with coupling delay. By the Lyapunov-Razumikhin method, a novel criterion is proposed to guarantee the global exponential synchronization of the coupled delayed network with distributed impulsive control in terms of matrix inequalities. The sum of coupling strength of the distributed impulsive control is minimized to save the control effort.

"*A novel mathematical formula for retrieval algorithm*" by Y. Qin et al. proposes a method to retrieve mathematical formula in LaTeX documents. Firstly, it represents the retrieved mathematical formula by binary tree according to its LaTeX description, normalizing the structure of the binary tree and obtaining the structure code. And then it searches the mathematical formula table that is named by the structure code and the formulate elements of the first two levels of the binary tree in the mathematical formula database.

"*Event-triggered H_∞ control for networked control systems with time-varying delay*" by H. Yan considers the H_∞ controller design problem for event-triggered networked control systems (NCSs), where the next task's release time and finishing time are predicted based on the sampled states. A new model of NCSs that involves the network conditions, state, and event-triggered communication strategy is proposed. Based on this model, some novel criteria for the asymptotic stability analysis and H_∞ state feedback controller design of the event-triggered NCSs with time-varying delay are established to guarantee a prescribed H_∞ disturbance rejection attenuation level.

"*State feedback control for stochastic feedforward nonlinear systems*" by L. Liu and M. Gao considers the state feedback stabilization problem for a class of stochastic feedforward nonlinear systems. By using the homogeneous domination approach, a state feedback controller is constructed to render the closed-loop system globally asymptotically stable in probability.

"*Output-feedback controller design of a wireless networked control system with packet loss and time delay*" by Z. Hong et al. investigates the problem of modeling and stabilization of a wireless networked control system (NCS) with both time-varying delay and packet-dropout. And the time-varying delay can be more or less than one sampling period. The wireless NCS is modeled as an asynchronous dynamic system (ADS) with three subsystems. Sufficient condition of the closed-loop NCS to be stable is obtained by using the ADS approach.

"*Residual generator-based controller design via process measurements*" by Z. Huang et al. proposes a scheme which embeds a residual generator into control loop based on realization of the Youla parameterization for advanced controller design. Basic idea of the proposed scheme is constructing the residual generator by using the solution of the Luenberger equations as well as the well-established relationship between diagnosis observer (DO) and the parity vector. And the core of the above idea is straightly using the process measurements to obtain the parity space based on the Subspace Identification Method (SIM), rather than establishing the system model.

"*Design of a TFT-LCD based digital automobile instrument*" by Y. Xu et al. proposes a design of a TFT-LCD based automobile instrument. With a 7-inch TFT-LCD and the 32-bit microcontroller MB91F599, the instrument could process various information generated by other electronic control units (ECUs) of a vehicle and display valuable driving parameters on the 7-inch TFT-LCD. The function of aided parking is also provided by the instrument. The significant contribution is to point out basic principles to be obeyed in circuits designing under on-board environment.

"*Metric learning method aided data-driven design of fault detection systems*" by G. Yan et al. proposes a metric learning based fault detection framework in fault detection. Meanwhile, a novel feature extraction method based on wavelet transform is used to obtain the feature vector from detection signals.

"*Sampling based Average Classifier Fusion*" by J. Hou et al. empirically investigates the behavior of soft labels and classifiers in average fusion and finds that by proper selection of soft labels and classifiers, the average fusion performance can be evidently improved. This result presents selection based average fusion as a better baseline, that is, a newly proposed classifier fusion algorithm should at least perform better than this baseline in order to demonstrate its effectiveness.

"*Distributed multitarget probabilistic coverage control algorithm for wireless sensor networks*" by Y. Tian et al. investigates the problem of multitarget coverage based on probabilistic detection model and proposes a distributed

probabilistic coverage algorithm for the WSN with multiple static targets. This algorithm is robust to the change of network size, and all the targets can be monitored at the requirement of network coverage probability.

"*The Finding and dynamic detection of opinion leaders in social network*" by B. Huang et al. presents a dynamic opinion rank algorithm to find out the opinion leaders in Chinese news. The proposed network model explicitly takes explicit and implicit links into account. Moreover, the proposed algorithm is able to conclude that the most influential comments and the opinion leaders were time-varying.

"*New strategy for analog circuit performance evaluation under disturbance and fault value*" by A. Zhang et al. proposes a novel strategy for analogy circuit online performance evaluation based on fuzzy learning and double weighted support vector machine (DWMK-FSVM). First, the double weighted support vector regression machine is employed to be the indirect evaluation means, relied on the college analog electronic technology experiment to evaluate analog circuit. Second, the superiority of fuzzy learning also is addressed to realize active suppression to the fault values and disturbance parameters. Moreover, the multikernel RBF is employed by support vector regression machine to realize more flexibility online such as the bandwidths tuning.

"*Whether and how to select inertia and acceleration of discrete particle swarm optimization algorithm: a study on channel assignment*" by M. Jin et al. proposes a strategy scheme and the selection of inertia and acceleration on whether the inertia section should be abandoned and how to select the appropriate acceleration in order for DPSO to show the best convergence performance. They are verified to have the advantage to channel assignment in three respects of convergence rate, convergence speed, and the independency on the quality of initial solution.

In "*New strategy for analog circuit performance evaluation under disturbance and fault value*" by A. Zhang et al., the authors design a peer-to-peer location based notification system Phoenix and focus on the design of the key component message controller. The results show Phoenix can satisfy the user-specified notification performance with the low transmission overhead.

In "*Coarse-grain QoS-aware dynamic instance provisioning for interactive workload in the cloud*" by J. Wan et al., The authors investigated the coarse-grain QoS-aware dynamic instance provisioning problem for interactive workload in the cloud computing. For self-similar traffic in internet they studied the percentile delay constraint. To solve the problem, they proposed a dynamic instance provisioning algorithm and a learning algorithm to design the instance rental policy. The effectiveness of the algorithms was verified by simulations.

"*Fast consensus tracking of multiagent systems with diverse communication delays and input delays*" by C.-X. Yang et al. investigates the consensus tracking problem for discrete-time multiagent systems with input and communication delay. A sufficient condition is obtained over a directed graph based on the frequency-domain analysis. A fast decentralized consensus tracking conditions based on increment PID algorithm is discussed for improving convergence speed of the multiagent systems.

"*Optimal placement of actors in WSANs based on imposed delay constraints*" by C. Yang et al. The authors find a method to determine the accurate number of actors which enables them to receive data and take actions in an imposed time-delay. The k-MinTE and the k-MaxTE clustering algorithm are proposed to form the minimum and maximum size of cluster, respectively. In those clustering algorithms, actors are deployed in such a way that sensors could route data to actors within k hops. Then, clusters are arranged by the regular hexagon.

"*Information exchange rather than topology awareness: cooperation between P2P overlay and traffic engineering*" by J. Zhao et al. The authors investigated cross-layer conflict between P2P overlay and ISP underlay and proposed a solution to use cooperation rather than hyperselfish topology-awareness. They illustrate the suboptimal profit of hyperselfish initiator based on two dynamic game models. Simulation results demonstrated that the SC model with path classes can improve costs for both layers and decrease the computation time of achieving the stable equilibrium.

"*Robust decentralized adaptive neural control for a class of nonaffine nonlinear large-scale systems with unknown dead zones*" by H. Wang et al. investigates the problem of robust decentralized adaptive neural stabilization control is investigated for a class of nonaffine nonlinear interconnected large-scale systems with unknown dead-zones. In the controller design procedure, RBF neural networks are applied to approximate packaged unknown nonlinearities and then an adaptive neural decentralized controller is systematically derived without requiring any information on the boundedness of dead-zone parameters. Simulation study is provided to demonstrate the effectiveness of the developed control scheme.

In "*An overview of networked control of complex dynamic systems*" by H. Yan, the authors focus on network imperfections and review the related studies, paying special attention to those carried out since the publishing dates of the surveys referred to. Some future research is also proposed. The main objective of the paper is to provide readers with an overview of the NCSs and a vision for future development. The other objective is to provide a tutorial on NCSs.

In "*Design of attitude control system for UAV based on feedback linearization and adaptive control*" by W. Zhou et al., the feedback linearization and model reference adaptive control (MRAC) are integrated to design the attitude control system for a fixed wing UAV. Simulation results indicate that the system performance indexes including maximum overshoot, settling time (2% error range), and rise time obtained by MRAC are better than those by PID.

"*The research on modeling and simulation of TFE polymerization process*" by J. Sun et al. deals with the problem of modeling and simulation of TFE polymerization process. The authors use the emulsion polymerization method at background to carry out a semibatch reactor system. Upon the actual production conditions, simulation process under the steady state conditions is used to analyze the effects of the changes on operating conditions; the corresponding dynamic model is created to analyze the impact of the changes of conditions on the entire system.

"*Design and stability analysis of uncertain networked predictive control systems with multiple forward channels*" by H. Song. is concerned with the design and stability of networked predictive control for uncertain systems with multiple forward channels. The delays and packet dropouts are distributed such that the classic networked predictive control (NPC) needs modifications to be implemented. An improved control signal selection scheme with distributed prediction length is proposed to increase the prediction accuracy and hence achieve better control performance.

"*Impact of social network and business model on innovation diffusion of electric vehicles in China*" by D. Y. Kong and X. H. Bi uses the theory of network control to analyze the influence of network forms on EV diffusion in China, especially focusing on the building of EV business models (BMs) and the resulting effects and control on the diffusion of EVs. They can find the appropriate network forms and BMs for EVs which is suitable to the local market conditions.

In "*An improved car-following model in vehicle networking based on network control*" by D.-Y. Kong and H. Y. Xu, a car-following model using vehicle networking theory is established, based on network control principle. The car-following model, which is an improvement of the traditional traffic model, describes the traffic in vehicle networking condition. The impact that vehicle networking has on the traffic flow is quantitatively assessed in a particular scene of one-way, no lane changing highway. The examples show that the capacity of the road is effectively enhanced by using vehicle networking.

"H_∞ *control of supply chain based on switched model of stock level*" by J. Luo and W. Yang is concerned with the problem of H_∞ control for a class of discrete supply chain systems. A new method based on network control technique is presented to address this issue. Supply chain systems are modeled as networked systems with stochastic time-delay. Sufficient conditions for H_∞ controller design are given in terms of a set of linear matrix inequalities, based on which the mean-square asymptotic stability and H_∞ performance are satisfied for such systems.

"*Bayes network based collaborating control algorithm in active multicamera network with applications to object tracking*" by R. Zhao et al. considers the problem for an active camera network framework is designed for human detection and tracking by optimizing the cameras collaborating control. A multicamera collaborating control algorithm is proposed based on Bayes network. The proper human feature selection is also concerned to improve the tracking precision. Experimental results on real world environment indicate the effectiveness and efficiency of proposed framework and algorithm.

"*A Bayesian network method for quantitative evaluation of defects in multilayered structures from Eddy current NDT signals*" by B. Ye et al. proposes to evaluate defects quantitatively from Eddy current NDT signals using Bayesian networks (BNs). BNs are a useful method in handling uncertainty in the inspection process, eventually leading to the more accurate results. The domain knowledge and the experimental data are used to generate the BN models. The models are applied to predict the signals corresponding to different defect characteristic parameters or to estimate defect characteristic parameters from Eddy current signals in real time.

"*Multiagent and particle swarm optimization for ship integrated power system network reconfiguration*" by Z. Wang et al. establishes the simplified network model and reconfiguration mathematical model of SIPS. PSO and multiagent technology are analyzed. Regional feeder agents are defined. Combining with multiagent and PSO, MAPSO is presented. In this algorithm, regional feeder agents communicate with adjacent agents to accomplish SIPS network reconfiguration.

In "*Fault diagnosis system based on multiagent technique for ship power system*" by Z. Wang et al., a multiagent fault diagnosis system is established with FED-Agent and other functional agents. Considering the characteristics of agent, the multiagent system processes both autonomy and interactivity. It can solve fault diagnosis problem of ship power system effectively.

In "*Eddy current inversion models for estimating dimensions of defects in multilayered structures*" by B. Ye et al., two effective approaches have been proposed to estimate the defect dimensions. The first one is a partial least squares (PLS) regression method. The second one is a kernel partial least squares (KPLS) regression method. The comparison results demonstrate the feasibility and validity of the proposed two methods.

"*A new three-dimensional indoor positioning mechanism based on wireless LAN*" by J. Cheng et al. proposes a hybrid approach in this paper using k-medoids algorithm to partition the set of fingerprints into several subsets first and then we reduce the dimension of fingerprints of every subset on which a multicategory SVM is used to train, outperforming the approach just using SVM to train on all large-dimension fingerprints, in terms of error distance resolution.

"*Event-triggered average consensus for multiagent systems with time-varying delay*" by Z. Wang et al. investigates average consensus for multiagent systems with time-varying delays. A reducing dimension multiagent systems model is presented firstly. Using event-triggered strategy to reduce network load, a comprehensive model is then proposed, which considers communication delays and triggered issue. Further, the event-triggered average consensus stability of multiagent systems with fixed directed/undirected graph is analyzed, and sufficient conditions are provided.

In "*Steady modeling for an ammonia synthesis reactor based on a novel CDEAS-LS-SVM model*" by Z. Liu et al., a steady-state mathematical model is built in order to represent plant behavior under stationary operating conditions. A novel modeling using LS-SVR based on Cultural Differential Evolution with Ant Search is proposed. LS-SVM is adopted to establish the model of the net value of ammonia. The modeling method has fast convergence speed and good global adaptability for identification of the ammonia synthesis process.

"*Group synchronization of nonlinear complex dynamics networks with sampled data*" by M. Li et al. considers the group synchronization of complex dynamical networks with sampled data. Using the Lyapunov method, the group synchronization of the nonlinear complex networks is analyzed. All the nodes in each group can converge to own synchronous

state asymptotically, if the sampled period satisfies some matrix inequality conditions.

In "*Monitoring of multimode processes based on quality-related common subspace separation*" by Y. Fan et al., the authors aimed at developing a new monitoring approach for multimode processes based on quality-related common subspace separation. In the model, the data set forms a larger space when the correlation between process variables and quality variables are considered. The whole space is decomposed as quality-related common subspace, quality-related specific subspace, and the residual subspace. The effectiveness of the proposed approach was verified by simulations.

"*A new mechanism for network monitoring and shielding in wireless LAN*" by J. Cheng et al. investigates various issues about wireless security, analyzing numerous problems in implementing the WLAN. They implemented an actual wireless LAN monitoring system to monitor the network data transmission, allowing users to understand the situation of device. What is more, the system analyzes and records ARP, RARP, IP, UDP, TCP, ICMP, and other protocols efficiently and flexibly.

In "*A discrete group search optimizer for hybrid flowshop scheduling problem with random breakdown*" by Z. Cui et al. The authors introduce the hybrid flowshop scheduling problem with random breakdown (RBHFS) together with a discrete group search optimizer algorithm (DGSO). In particular, two different working cases, preempt-resume case and preempt-repeat case, are considered under random breakdown.

In "*Cultural-based genetic tabu algorithm for multiobjective job shop scheduling*" by Y. Yang et al., the authors propose a novel quad-space cultural genetic tabu algorithm (QSCGTA) to solve such problem. This algorithm provides a different structure from the original cultural algorithm in containing double brief spaces and population spaces. They also present a bidirectional shifting for the decoding process of job shop scheduling.

"*Fundamental issues and prospective directions in networked multirate control systems*" by W. Zhiwen and G. Ge has introduced and reviewed the fundamental issues and prospective directions for NMCSs. One can draw the conclusions that the introduction of multirate sampling in NCSs, on the one hand, will make the modeling, analysis, and synthesis of NCSs more complicated and challenge the achieved theoretical results; on the other hand, it will bring opportunities toward some higher goals for NCSs.

"*Nonlinear disturbance observer based robust tracking control of pneumatic muscle*" by Y. Mohamed et al. proposes nonlinear disturbance observer based control law (NDOBC) providing a relatively new thread for the control of PMA. The advantage of this method not only is reflected in its high accuracy, but also manifests itself in convenience. The proposed approach represents a simple, yet robust mechanism for guaranteeing finite time performance of zero error condition.

"*Robust H_∞ filtering for networked control systems with random sensor delay*" by S. Xiao et al. investigates the robust H_∞ filtering problem for a class of network-based systems with random sensor delay. Using the Lyapunov function and Wirtinger's inequality approach, the sufficient conditions are derived to ensure that the filtering error systems is exponentially stable with a prescribed H_∞ disturbance attenuation level and the filter design method is proposed in terms of LMIs. The effectiveness of the proposed method is illustrated by a numerical example.

"*A local and global search combined particle swarm optimization algorithm and its convergence analysis*" by W. Lin et al. presents a LGSCPSO algorithm, and simulations show that it is effective. The performance of the new approach is evaluated in comparison with OPSO algorithm for eight representative instances with different dimensions and obtained results show that LGSCPSO algorithm is effective for solving optimization problems.

"*Switched quantization level control of networked control systems with packet dropouts*" by S. Wang et al. investigates the relationship between the maximum allowable dropout bound and the quantization density. The NCS is described as a time-delay switched system with constrained switching signals. A switched dynamic output feedback controller with prescribed disturbance attenuation level is designed via a cone complement linearization approach. A novel stability criterion is obtained by switched system theory.

"*Impulsive consensus tracking of multiagent systems with quantization and input delays using position-only information*" by H. Zhou et al. investigates the consensus tracking problem for second-order multiagent systems without/with input delays. Randomized quantization scheme is considered in the communication channels, and impulsive consensus tracking algorithms using position-only information are proposed. Based on the algebraic graph theory and stability theory of impulsive systems, sufficient and necessary conditions for consensus tracking are studied. It is found that consensus tracking for second-order multiagent systems without/with input delays can be achieved by appropriately choosing the sampling period and control gains which are determined by second-/third-degree polynomials.

Of course, the selected topics and papers are not a comprehensive representation of the area of this special issue. Nonetheless, they represent the rich and many-faceted knowledge that we have the pleasure of sharing with the readers.

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