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*Editorial*

# Modeling and Control of Complex Dynamic Systems 2013

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## 1. Introduction

The concept of complex dynamic systems arises in many research fields and practical applications, which can be found anywhere such as in the areas of energy generation and distribution, ecosystems, health delivery, safety and security systems, telecommunications, transportation networks, biomedical systems, and the rapidly emerging research topics seeking to be understood and analyzed. A complex process may be characterized by a system with environmental uncertainties, communication time delay, stochastic perturbation, hybrid dynamics, distributed dynamics, chaotic dynamics, and systems with collective behavior. As a result, modeling and control of a complex system are interesting but challenging. Following the great success of the special issue last year [1], the guest editorial team is pleased to organize the second special issue for "Modelling and Control for Complex Dynamic Systems."

This special issue aims to provide a platform for researchers to discuss various mathematical methods and techniques for modeling and control of complex dynamic systems and to identify critical issues and challenges for future investigation in this field. The special issue received 56 submissions, and 14 papers are selected after a strict peer review procedure, indicating an acceptance rate at 25%.

## 2. Modeling of Complex Dynamic Systems

Partial differential equations can be used to describe infinite-dimensional dynamics of a complex process. In the paper by Khosroushahi et al. the infinite-dimensional dynamics of a prototype micro-fluidic thermal process is investigated for genetic analysis purposes. Compared with conventional lumped modeling approaches, the infinite-dimensional dynamic model is more effective to be used to develop a precise control framework to meet the very tight performance requirements. The equations of the dynamic models are solved analytically and the proposed models are validated by a known experimentally verified model. The model framework can be used for designing a precise tracking controller applicable to the selected Lab-on-a-Chip device.

Model reduction is a technique to reduce model dimensions particularly for a high-dimensional system. It is noted that, for certain types of nonlinear partial differential equations, some neglectful modes could be crucial in the modeling although they only represent a tiny amount of energy. In the work by J. Shuai and X. Han, an optimal EEF (empirical eigenfunction) method is proposed for model reduction of nonlinear partial differential equations, which is based on the basis function transformation from the initial EEFs. The present model reduction method can generate a lower-dimensional dynamic model but keep dynamical information of neglectful modes, leading to a more precise model for the partial differential equations. The effectiveness and feasibility for model reduction are verified by simulated results.

Recently, uncertainty theory has attracted attention on the modeling of complex problems. For instance, flight scheduling, practically for the case with irregular flights, is a real-time optimization problem. Due to the uncertainty of the problem and insufficiency of the data in the decision-making procedure, the traditional modeling tool (such as probability theory) becomes invalid. In the paper by D. Mou and W. Zhao, the uncertainty theory is applied to develop an uncertain programming model with constraints. In the model, the total delay minutes of passengers are considered as the optimization objective by reassigning fleets in response to the irregular flights with the constraints in available resources and estimated cost of airlines. The model and algorithms are demonstrated and illustrated by a numerical example.

Ordinary differential equations are an alternative for modeling. In the work by M. Liu and Y. Xiao an improved Susceptible-Infected-Susceptible (SIS) epidemic diffusion model with population migration between two cities is modeled. The global stability conditions are discussed for both disease-free equilibrium and endemic equilibrium. Unequal migration rates are taken into account and only susceptible individuals can migrate between the two cities, which form the main feature of the proposed model. In terms of numerical simulation results, the stability of the epidemic diffusion system is demonstrated.

Data-driven method is a powerful tool for modelling of a dynamic system. In the paper by Q. Lu et al. a mathematical model of vehicle crash, namely, LPV-ARMAX model, is established by using data-driven techniques to simulate the car-to-pole collision with different initial impact velocities. The parameters of the LPV-ARMAX model are assumed to have dependence on the initial impact velocities, and the LPV-ARMAX model is comparatively simple and applicable to predict the responses of new collision situations different from the ones used for identification. Moreover, the high fidelity of the LPV-ARMAX model is demonstrated by using real test data.

Varying-coefficient modeling method is useful to describe a dynamic process. In the paper by Y. Song et al. the block empirical likelihood procedure is employed to establish a longitudinal single-index varying coefficient model with the capability of accommodating within-group correlations. In comparison with normal approximations, the proposed method does not need a consistent estimator for the asymptotic covariance matrix, indicating an easier way to conduct inference for parametric components of the model. The proposed modeling methods are demonstrated by numerical simulations.

## 3. Control of Complex Dynamic Systems

Dynamics control of a complex system is interesting but challenging. In the work by C. Nejneru et al. a novel approach is addressed for the control of complex systems dynamics using nondifferentiability of the movement curves in a complex system. The standard properties of the complex system such as emergence, self-organisation, and adaptability can be controlled through the non-differentiability of the motion curves of the subsystems that constitute the complex system.

Electromechanical coupling for mechanical elastic energy storage forms a complex system. In the work by Y. Yu and Z. Mi the modeling and control of the complex electromechanical system are both investigated. The theory of direct feedback linearization is applied to decouple the nonlinear dynamic model and convert the developed model from nonlinear to linear. Optimal control theory is then utilized to achieve speed tracking control for the linearized systems. The simulation results have demonstrated the feasibility and efficiency of the proposed model and control algorithms by evaluating three scenarios.

Control and obstacle avoidance for hybrid multiagent systems is an interesting topic. In the paper by D. Xue et al., an H1 formation method is proposed to handle a group of agents navigating in either a free or an obstacle-laden environment with changing formation subject to internal or external events. The disturbed situation and the attenuation level of the obstacle avoidance can be characterized by the formation information and its H1 formation norm, respectively. Simulation results show that the proposed formation algorithms can effectively avoid penetration into obstacles while accomplishing the prespecified global objective.

Two-point boundary value problems for infinite-dimensional dynamical systems were first introduced by Kong in 2010 (see pages 121-122 in [2]). This kind of problems is an emerging topic to solve the distributed parameter control systems. The survey paper contributed by D. X. Kong and E. Wu, describes a new type of distributed parameter control systems related to two-point boundary value problems for infinite-dimensional dynamical systems and reviews the results which have been obtained so far. Furthermore, some unresolved questions are proposed which aim to stimulate further researches in this interesting topic.

In the paper by M. Shi and J. Li, distributed adaptive synchronization control of complex dynamical networks with nonlinearly derivative coupling is investigated. An effective distributed adaptive technique is addressed to eliminate the effect of time-varying parameters and synchronize the considered network with a given trajectory in the sense of square error norm. The applicability and feasibility of the approach are illustrated by an example.

The work, contributed by Y. Shi et al., dealt with adaptive synchronization problem of complex dynamical networks with nonlinear dynamics. By using Lyapunov method and local adaptive strategy, it is shown that the network can synchronize with the synchronous states. Moreover, the convergent speed of complex dynamical networks can be increased via designing a state predictor. The results are finally demonstrated and illustrated by numerical simulations.

## 4. Computing/Evaluating Algorithms for Complex Networks

The computation of the average shortest-path length for a large scale-free network needs much memory space and computing time. In the work by G. Mao and N. Zhang, the relationship between the computing time of a single-source shortest-path length of node and the features of nodes are investigated. A native array and multimap representation of the network are addressed to reduce the memory consumption of the network. A simplified load-balancing model is applied to a network of tens of millions of nodes. By using experiments, it is shown that the model proposed can be used to effectively solve the load-imbalance problem of a large scale-free network.

In the work by J. Hu et al., multi-angle social network recommendation algorithms are addressed and the similarity network evaluation method is proposed. The six algorithms for multi-angle social network recommendations are investigated and evaluated. Compared with the traditional recall/precision method, the similarity network evaluation method has an advantage of the effectiveness, visualization, and simple procedure for use. The comparisons of the six algorithms are finally discussed, leading to explicit comments on the algorithms.

## 5. Conclusion

The 14 selected papers can roughly be categorized into modeling of complex systems, control of complex systems, and computing/evaluating algorithms of complex networks, which can reflect recent progresses in the research fields on complex dynamic systems to some broadness and deepness. We hope this special issue will further stimulate the researches of complex dynamic systems from a variety of academic societies and industrial communities.

## Acknowledgments

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