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Open Challenges on the Stability of Complex Systems: Insights of Nonlinear Phenomena with or without Delay

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New developments and applications of science and industry demand no conventional modeling approaches where the increase of complexity is a common denominator. Due to nonlinear dynamics, many of the resulting mathematical models are complex systems. For example, the inherent nonlinear dynamics of physical systems make it difficult to analyze a large majority of these complex systems, giving them a wide variety of dynamic behavior. Another well-known example is the delay phenomena where the information on the state of the system in past events can be very valuable for prediction and control. In recent years, the study to determine stability and stabilization of nonlinear phenomena has had a great research interest, developing novel methods. Thus, some of these methods have been implemented to study controls for systems with delay. In this special issue new insights into the stabilization of particular nonlinear systems and systems with delay are introduced. We are sure that the selected manuscripts will be useful for the reader, providing valuable contributions, novel methods, and overall good proposals.

In the paper “Implementation of a Controller to Eliminate the Limit Cycle in the Inverted Pendulum on a Cart”, M. Antonio-Cruz et al. discuss a frequency response-based linear controller. The main aim of this paper is to study a control strategy to eliminate limit cycle in the inverted pendulum on a cart generated by the dead-zone, induced by static friction.

The paper “Dynamics induced by delay in a nutrient-phytoplankton model with multiple delays” by C. Dai et al. studies a nitrogen-phosphorus-phytoplankton model described by a couple of delay differential equations to study the effect of delay on the nutrient-phytoplankton dynamics. The authors prove that the positive equilibrium is always globally asymptotically stable when there are no delays and the model may undergo a Hopf bifurcation as the delays are varied.

The paper “Simulation and Analysis of the Complex Behavior of Supply Chain Inventory System Based on Third-Party Logistics Management Inventory Model with No Accumulating of Unsatisfied Demand” by Z. Zhang et al. is a study based on third-party logistics management inventory models. The authors construct a dynamic model and they give conditions on the parameters for obtaining stability and getting useful conclusions; for example, a reasonable decision can make the inventory of the warehouse distribution system stable to a small interval.

The paper “Stability of the Evolutionary Game System and Control Strategies of Behavior Instability in Coal Mine Safety Management” by X. Wang et al. analyzes the stability of a dynamical game system with flexible and inflexible costs and penalties. The analysis carried out provides a theoretical basis for a more reasonable and effective safety management policy, in coal mine safety system. From such analysis, the authors conclude that combined mechanisms of incentive rewards
and flexible penalties can optimize and control the instability of the behavior strategy selection in the safety supervision model.

The paper "Synchronization Control in Reaction-Diffusion Systems: Application to Lengyel-Epstein System" by A. Ouannas et al. considers the complete synchronization of a large class of reaction-diffusion coupled systems. The class of systems considered is very general: the nonlinear term only requires continuity in order to attain complete synchronization with nonlinear controllers, and the continuity plus a boundedness condition in order to attain it with linear controllers. The authors study a model derived from a chemical-physics system, i.e., the Lengyel-Epstein system. The complete synchronization is in both cases (linear and nonlinear) verified via Lyapunov stability theory.

The paper "Hybrid Functions Direct Approach and State Feedback Optimal Solutions for a Class of Nonlinear Polynomial Time-Delay Systems", by M. K. Bouafoura and N. B. Braiek, presents an approximate method to determine the optimal open loop solution and nonlinear delay-dependent state feedback suboptimal control for a class of nonlinear polynomial time-delay systems by transforming the dynamical optimal control problem into a static optimization problem. In the proposed numerical method, Legendre polynomials are used.

In the paper "Consensus of Multiagent Systems Described by Various Noninteger Derivatives", G. Nava-Antonio et al. analyze recent developments in Lyapunov stability theory to determine the asymptotic stability of particular fractional dynamical systems. The results are applied to study the consensus of a fractional multiagent system with linear and nonlinear dynamics.

In the paper "New Results on the Control for a Kind of Uncertain Chaotic Systems Based on Fuzzy Logic", B. Wang and L. L. Chen analyze a single-dimensional controller, based on fuzzy logic and Lyapunov theory, to control uncertain nonlinear chaotic systems. The effectiveness of the designer controller is discussed through typical numerical simulations.

A systematic study of the local and the global stability of traveling wave solutions to the Lotka-Volterra diffusive model is investigated in "Stability of Traveling Waves to the Lotka-Volterra Competition Model" by A. Alhasanat and C. Ou. The local stability is given using the method of spectrum analysis. However, for global stability, the authors construct an upper and a lower solution to the Lotka-Volterra system and prove their convergence to the traveling wave.

The paper "New Results on Stability Analysis of Uncertain Neutral-Type Lur'e Systems Derived from a Modified Lyapunov-Krasovskii Functional" by W. Duan et al. is concerned with the problem of the absolute and robustly absolute stability for the uncertain neutral-type Lur'e system with time-varying delays. Here, the quadratic generalized free-weighting matrix inequality technique is used to reduce the conservatism of the stability conditions. Unlike previous results, the matrix inequalities of the stability criteria proposed in this paper are converted to LMIs via the properties of quadratic functions application, which can be solved easily by Matlab LMI-toolbox.

The paper "Parameter Identification and Adaptive Control of Uncertain Goodwin Oscillator Networks with Disturbances" by J. Zhang et al. studies a drive-response system based on a differential equation model of mammals' circadian rhythms, where the suprachiasmatic nucleus (SCN) of the hypothalamus was modeled by a Goodwin oscillator and the vasoactive intestinal polypeptides (VIP) were modeled by a Van der Pol oscillator. Outer synchronization in a drive-response system has been achieved by considering effective parameter updating laws to identify the unknown parameters and designing adaptive control strategies. This paper has designed a targeted adaptive controllers to synchronize a drive-response system based on Goodwin oscillator network.

Conflicts of Interest

The editors declare that they have no conflicts of interest regarding the publication of this special issue.

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