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Editorial

New Trends on Modeling, Design, and Control of Chaotic Systems

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Nowadays, one of the most studied phenomena is chaos into the nonlinear dynamical systems. For deterministic chaos to exist, a nonlinear dynamical system must have a dense set of periodic orbits and be transitive and sensitive to initial conditions. Their significance has been increased during the last decade because of several applications in diverse fields ranging from living systems, such as synchronization in neurobiology, chemical reactions among pancreatic cells, and social, economical, or political events, to nonliving systems including robotics, low power high-speed data transceivers for medical applications, chaotic electrochemical oscillators, encrypted communications, and control algorithms for motor drivers in electric vehicles. However, in order to exploit all the possible engineering applications, the open problems about chaotic systems need to be addressed by proposing novel theoretical and practical approaches focused on modeling, simulation, synthesis, design, control, and circuit implementation.

Lately, several synchronization schemes to coupling two chaotic systems, at least, have attracted increasing attention due to the fact that they are the core of many chaos-based secure communications technologies. Also, the current research interest in proposing novel multiscroll chaotic systems with self-excited or hidden attractors to increase the complexity has augmented considerably. Each new chaotic system is a potential candidate to improve chaos-based applications. Additionally, chaotic systems have been recently used to analyze financial models trying to predict the complexity of the markets with a huge effect in the global economy.

Therefore, the overall purpose of this special issue lies in gathering the latest scientific trends on the topics of chaotic systems with emphasis on real-world engineering applications. We had received a total of 28 submissions where the authors are from geographically distributed countries (China, Vietnam, Greece, Poland, Taiwan, Serbia, Iran, Tunisia, Turkey, Saudi Arabia, Egypt, Mexico, and Czech Republic). This reflects the high impact of the proposed topic and the seniority in organization of this special issue.

In the paper "Uncertain Unified Chaotic Systems Control with Input Nonlinearity via Sliding Mode Control," Z. Shen et al. have studied the stabilization problem for a class of unified chaotic systems subject to uncertainties and input nonlinearity. Based on the sliding mode control theory, authors present a new method for the sliding mode controller design and the control law algorithm for such systems. In order to achieve the goal of stabilization unified chaotic systems, the presented controller can make the movement starting from any point in the state space reach the sliding mode in limited time and asymptotically reach the origin along the switching surface. Compared with the existing literature, the proposed controller has many advantages, such as having small chattering, having good stability, and being less conservative.

In the paper "Complexity Analysis of a Triopoly Cooperation-Competition Game Model in Convergence Product Market," L. Zhao et al. consider a tripartite cooperation-competition game model for the convergence product market, whose products are compounds of two base products or services. An early convergence product firm monopoly in this market and two potential entrants from the base products decide to cooperate with another to compete with the monopolist. Authors analyzed factors that affect existence and local stability of the Nash equilibrium. Rich nonlinear dynamic behaviors like bifurcation, chaos, and attractors are presented to explain the complex relationships between the three players. Results showed that the pulling effect on profit for the united R&D activity can significantly enlarge the stable region. Too frequently adjusted price strategy will bring the system into chaos. A parameter feedback control method is given to control the chaotic system and the authors numerically verified its effectiveness. This study has significant values to understand the fluctuations in related convergence product market.

In the paper "Hopf Bifurcation, Positively Invariant Set, and Physical Realization of a New Four-Dimensional Hyperchaotic Financial System," G. Kai et al. introduce a new four-dimensional hyperchaotic financial system on the basis of an established three-dimensional nonlinear financial system and a dynamic model by adding a controller term to consider the effect of control on the system. In terms of the proposed financial system, the sufficient conditions for nonexistence of chaotic and hyperchaotic behaviors are derived theoretically. Then, the solutions of equilibria are obtained. For each equilibrium, its stability and existence of Hopf bifurcation are validated. Based on corresponding first Lyapunov coefficient of each equilibrium, the analytical proof of the existence of periodic solutions is given. The ultimate bound and positively invariant set for the financial system are obtained and estimated. There exists a stable periodic solution obtained near the unstable equilibrium point. Finally, the dynamic behaviors of the new system are explored by theoretical analysis by using the bifurcation diagrams and phase portraits. Moreover, the hyperchaotic financial system has been simulated and implemented to confirm the results of the numerical integrations and its real contribution to engineering.

In the paper "Sliding Mode Control of Discrete Chaotic System Based on Multimodal Function Series Coupling," F. Hu has proposed a new sliding mode control model of discrete chaotic systems based on multimodal function series coupling to overcome the shortcomings of the standard PSO algorithm in multimodal function optimization. Firstly, a series coupled PSO algorithm (PP algorithm) based on multimodal function is constructed, which is optimized by multipeak solution on the basis of the standard PSO algorithm. Secondly, the improved PSO algorithm is applied to search all the extreme points in the feasible domain. Thirdly, the Powell method is used to perform the local optimization of the search results, and the newly generated extreme points are added to the extreme point database according to the same peak judgment operator. Finally, the long training time of PP algorithm can be overcome by the characteristics of fast convergence rate of the cloud mutation model. And also, both the population size and the redundancy can be reduced. Then, the clonal selection algorithm is used to keep the diversity of the population effectively. Simulation results of the sliding mode control of discrete chaotic systems have shown that the improved PSO algorithm obviously improves the response speed, overshoot, and so on.

In the paper "Synchronization in Coupled Multistable Systems with Hidden Attractors," G. PM and T. Kapitaniak present the results of coupling multistable systems which have hidden attractors with each other. Three modified Sprott systems were coupled and their synchronization was observed. The final state of the synchronized system changes with the change in the coupling strength. This was observed for two different types of coupling, one with a single variable and the other with two system variables.

In the paper "Stability and Multiscroll Attractors of Control Systems via the Abscissa," E.-C. Díaz-González et al. have established an approach to generate multiscroll attractors via destabilization of piecewise linear systems based on Hurwitz matrix. First the authors present some results about the abscissa of stability of characteristic polynomials from linear differential equations systems; that is, they consider Hurwitz polynomials. The starting point is the Gauss-Lucas Theorem, the authors provide lower bounds for Hurwitz polynomials, and by successively decreasing the order of the derivative of the Hurwitz polynomial one obtains a sequence of lower bounds. The results are extended in a straightforward way to interval polynomials; then authors apply the abscissa as a measure to destabilize Hurwitz polynomial for the generation of a family of multiscroll attractors based on a class of unstable dissipative systems (UDS) of type affine linear.

Acknowledgments

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will enjoy reading this special issue devoted to this exciting and fast-evolving field as much as we have done.

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