Editorial

Theoretical and Computational Advances in Nonlinear Dynamical Systems 2018

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After the success of last year's special issue, we have received more than 30 submissions for TCAN 2018. Twelve articles, containing the studies in chaos and synchronization, nonlinear evolution equations, and applied dynamical systems, are accepted after strict review process. A new Guest Editor, Christos Volos, from Aristotle University of Thessaloniki, was invited to serve in the areas of chaotic systems and synchronization. We believe these articles, including their bibliographic resources, will substantially improve the quality of our special issue and show wide interest to the readers in nonlinear communities.

Chaos belongs to the field of "Nonlinear Oscillations Theory," which was initiated in the previous century. The experiment that boosted the consideration of chaotic behavior was due to Lorenz [1]. In 1961, working in a simplified model of atmospheric transfer with three nonlinear differential equations, he observed numerically that when making very small changes in the initial conditions he got a huge effect on their solutions. It was one evidence of the main properties of chaotic dynamics which was later known as sensitive dependence on initial conditions, also known as "Butterfly Effect." This property in fact had already been investigated from the topological point of view by Poincaré who described it in his monograph "Science and Method" [2].

For many years the property of chaos became undesirable, since it reduced the predictability of the chaotic system over long time periods. However, the scientific community was gradually becoming aware of this type of dynamical behavior. Some experiments, where abnormal results had been previously explained in terms of experimental error or additional noise, were evaluated for an explanation in terms of chaos. In the mid-70s, the term deterministic chaos was introduced by Li and Yorke in a famous paper entitled "Period Three Implies Chaos" [3]. Since then, a huge number of studies in chaotic phenomena and dynamical systems that produce chaos have been published.

The dynamics of a system displays chaotic behavior; when it never repeats itself, and even if initial conditions are correlated by proximity, the corresponding trajectories quickly become uncorrelated. As such, the possibility of two (or more) chaotic systems oscillating in a coherent and synchronized way seems to be not an obvious phenomenon. However, there are sets of coupled chaotic oscillators in which the attractive effect of a sufficiently strong coupling can counterbalance the trend of the trajectories to diverge. As a result, it is possible to reach full synchronization in chaotic systems since they are coupled by a suitable dissipative coupling. Chaos synchronization began in the mid-80s about coupling of discrete and continuous identical systems, evolving from different initial conditions [4–8]. These works immediately received a great deal of attention from the scientific community and opened up a wide range of applications outside the traditional scope of chaos and nonlinear dynamics research. Since then, various synchronization methods and several new concepts necessary for analyzing synchronization have been developed.

In this special issue, three articles are dedicated to the investigation of chaotic systems and their synchronization.

In "Fractional-Order Sliding Mode Synchronization for Fractional-Order Chaotic Systems," by C. Wang, some sufficient conditions, which are valid for the stability check of fractional-order nonlinear systems, are presented. Based on the aforementioned conditions, the synchronization of two fractional-order chaotic systems is investigated. The asymptotical stability of the synchronization error can be guaranteed by a proposed fractional-order sliding mode controller. The numerical examples show the feasibility of the proposed method.

In "Adaptive Fuzzy Synchronization of Fractional-Order Chaotic Neural Networks with Backlash-Like Hysteresis," by W. Fu and H. Liu, an adaptive fuzzy synchronization controller is designed for a class of fractional-order neural networks subjected to backlash-like hysteresis input. The stability of the closed-loop system, under the influence of the adaptive fuzzy controller, is rigorously analyzed based on the fractional Lyapunov stability criterion. Furthermore, fractional adaptation laws are established to update the fuzzy parameters. The simulation examples indicate the effectiveness and the robustness of the proposed control method.

In "Chaos in a System with an Absolute Nonlinearity and Chaos Synchronization," by V. K. Tamba et al., a system with an absolute nonlinearity is studied. The system is shown to be chaotic and has an adjustable amplitude variable, which is suitable for practical uses. Circuit design of such a system has been realized without any multiplier, and experimental measurements have been reported. In addition, an adaptive control has been applied to reach the synchronization of the system.

Nonlinear evolution equations (NEEs) play important roles in simulating the real dynamical behaviors that appear in various scientific and engineering fields. Analysis of the NEEs, especially for finding their solutions, is one of the main tasks in nonlinear communities. For integrable NEEs, there exist several effective methods, such as the inverse scattering transformation and the Hirota method, in deriving certain types of localized wave solutions, e.g., the soliton and breather solutions [9, 10]. For nonintegrable NEEs, multiple tools are employed to analyze their properties, among which the numerical methods are becoming powerful with the rapid development of computational resources.

In this special issue, six articles are included to demonstrate advances relating to the NEEs, from both of the analytic and numerical aspects.

In "Traveling Wave Solutions of Two Nonlinear Wave Equations by (G'/G)-Expansion Method," by Y. Shi et al., the (G'/G)-expansion method is employed to seek exact traveling wave solutions of two nonlinear wave equations: Padé-II equation and Drinfel'd-Sokolov-Wilson equation. Hyperbolic function solution, trigonometric function solution, and rational solution with general parameters are obtained. The solitary wave solutions and new traveling wave solutions can be derived when special values of the parameters are taken.

The advantageous Green's function method that originally has been developed for nonhomogeneous linear equations has been recently extended to nonlinear equations by Frasca. In "Nonlinear Green's Functions for Wave Equation with Quadratic and Hyperbolic Potentials," the author A.

Zh. Khurshudyan developed a rigorous numerical analysis of some second order one-dimensional wave differential equations with quadratic and hyperbolic nonlinearities by means of Frasca's method. Numerical error analysis in both cases of nonlinearity is carried out for various source functions supporting the advantage of the method.

In "The Global Existence and Uniqueness of the Classical Solution with the Periodic Initial Value Problem for One-Dimension Klein-Gordon-Zakharov Equations," by C. Sun and L. Li, the Galerkin method is applied to establish the approximate solutions for the one-dimension Klein-Gordon-Zakharov (KGZ) equations, and the local classical solutions are obtained. The authors also derive the existence and uniqueness of the global classical solutions of the KGZ equations by integral estimates.

In "CIP Method of Characteristics for the Solution of Tide Wave Equations," by Y. Nie et al., the Constrained Interpolation Profile/Method of Characteristics (CIP-MOC) is proposed to solve the tide wave equations with large time step size. The bottom topography and bottom friction are included to the equation of Riemann invariants as the source term. Numerical experiments demonstrate the good performance of the scheme. In addition, numerical tests with reflective boundary conditions are carried out by CIP-MOC with large time step size, and good results are obtained as well.

In "Reachable Set Bounding for a Class of Nonlinear Time-Varying Systems with Delay," by X. Zhu et al., the authors investigate the problem of reachable set bounding for a class of continuous-time and discrete-time nonlinear time-varying systems with time-varying delay. They use an approach which does not involve the conventional Lyapunov-Krasovskii functional, and propose new conditions such that all the state trajectories of the system converge asymptotically within a ball.

In "On the Convergence Ball and Error Analysis of the Modified Secant Method," by R. Lin et al., the authors have studied the convergence properties of a modification of secant iteration methods. This work introduced the convergence ball and error estimate of the modified secant method using a technique based on Fibonacci series.

In this special issue, we also include three articles focusing on application of the nonlinear dynamical systems in diffusion behavior, fluid, and solid mechanics.

In "Motion of a Spot in a Reaction Diffusion System under the Influence of Chemotaxis," by S. Kawaguchi, the motion of a spot under the influence of chemotaxis is considered. For this reason, a two-component reaction diffusion system, with a global coupling term and a Keller Segel type chemotaxis term, is presented. The existence of an upper limit for the velocity and a critical intensity for the chemotaxis, over which there is no circular motion, is proved. As a consequence the chemotaxis suppresses the range of velocity for the circular motion. This braking effect on velocity originates from the refractory period behind the rear interface of the spot and the negative chemotactic velocity.

In "A Study of the Transport of Marine Pollutants Using Adjoint Method of Data Assimilation with Method of Characteristics," by X. Li et al., the authors apply an adjoint method of data assimilation with the characteristic finite

difference scheme to marine pollutant transport problems and simulate the temporal and spatial distribution of marine pollutants. They show that their method can not only reduce simulation error to get a good inversion, but also enable larger time step size to decrease computation time and improve the calculation efficiency.

In "Dynamic Characteristics of Deeply-Buried Spherical Biogas Digesters in Viscoelastic Soil," by H. Hou et al., the vibration characteristics of a deeply-buried spherical methane tank in viscoelastic soil subjected to cyclic loading in the frequency domain are investigated. By introducing potential functions, the closed-form expressions for the displacement and the stress of the soil surrounding the tank are obtained. In addition, the effects of relative physical properties and geometrical parameters on the dynamics of the system are discussed.

Conflicts of Interest

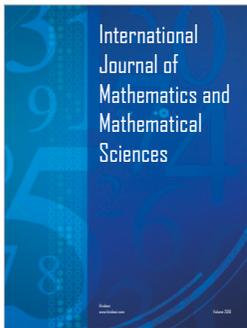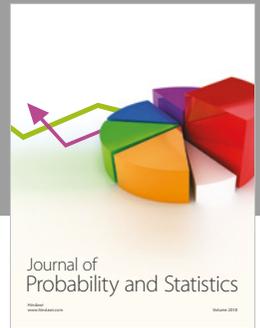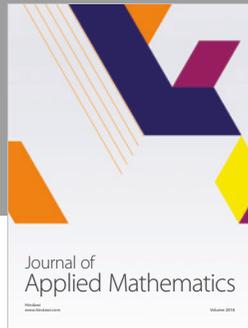The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgments

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