Journal of Computational and Nonlinear Dynamics

Guest Editorial

Special Issue: Nonlinear Dynamics: Models, Behavior, and Techniques

Over the past few decades, it has been well established that in both natural and engineering systems nonlinearity is one of the primary mechanisms for the generation of complexity. Examples range from nanoscales to geophysical-scales and include chaotic fluid dynamics in environmental settings, biological behavior ranging from cells and viruses to collective dynamics of animals and humans, engineering applications involving interactions of autonomous agents with their environment, as well as large amplitude oscillations, just to name a few. In all of these examples, many of which are considered in the present issue, nonlinearity is manifested through energy transfers between degrees-of-freedom, rapid loss of predictability, nonlocal frequency- and history-dependence, and non-Gaussian statistics with the possible occurrence of extreme transient responses.

In this special issue, the guest editors aim to illustrate many of the properties characterizing nonlinear dynamical systems as well as the associated modeling challenges and solutions. For many such systems, fractional calculus provides an attractive framework that conveniently captures the underling power laws in a deterministic and accurate way. We recall that the classical mathematical models of integer-order derivatives, including nonlinear models, do not work adequately in many cases where power laws have been reported. In particular, fractional calculus has drawn increasing attention in the study of anomalous behaviors, where the scaling power law of fractional order appears universal as an empirical description of several complex phenomena.

We should add that there is a large class of systems, in which even polynomial type of nonlinearities can lead to complicated behaviors. These behaviors include bifurcations of responses and energy transfers between temporal and spatial scales. An extreme manifestation of such nonlinear behaviors is the formation of internal instabilities that result in chaotic behavior and loss of predictability. A purely deterministic analysis in such cases has important limitations due to the inherently random character of the system, while the employment of stochastic methods can have tremendous benefits, including the parsimonious quantification of the system statistics, the development of stochastic closures representing the effects of the ignored degrees-of-freedom, as well as, the representation of the a priori unknown characteristics of excitation processes. It is critical, however that in all these stochastic modeling efforts, the underlying dynamical mechanism is taken into account as much as possible.

This special issue contains 14 high quality papers, a brief summary of which follows.

In the paper "First Integrals and Integrating Factors of Second-Order Autonomous Systems," by Támas Kalmár-Nagy and Balázs Sándor, a new method to construct first integrals for second-order autonomous systems without invoking a Lagrangian or Hamiltonian reformulation has been presented.

In the work "Nonlinear Modeling and Experimental Analysis of Vertically Aligned Carbon Nanotube Pads Under Uniaxial Compressive Loading," by Nicholas Candelino and Nader Jalili, close-fitting continuous model of the midfrequency dynamics has been studied by utilizing a combination of phenomenological and identification-based methodologies.

In the paper "Chaos Synchronization of Fractional-Order Chaotic Systems With Input Saturation," by Pitcha Khamsuwan, Teerawat Sangpet, and Suwat Kuntanapreeda, the sufficient stability conditions for achieving the synchronization has been developed from the basis of a fractional-order extension of the Lyapunov direct method, a new lemma of the Caputo fractional derivative, and a local sector condition. In "Fractional Dynamics of an Infection Model With Time-Varying Drug Exposure," by Carla M. A. Pinto and Ana R. M. Carvalho, the authors have considered a fractional order model for the human immunodeficiency virus dynamics, wherein time-varying drug-exposure and drug-resistance have been assumed. In the study "On Finite Part Integrals and Hadamard-Type Fractional Derivatives," by Li Ma and Changpin Li, the authors have investigated the relationship between Hadamard-type fractional derivatives and finite part integrals in a Hadamard sense. In the work "On Coexistence of Fractional-Order Hidden Attractors," by Manashita Borah, new fractional-order models are considered and the existence of chaos and hyperchaos in these systems has been discussed. In the work "Enlarged Controllability of Riemann–Liouville Fractional Differential Equations," by Touria Karite, Ali Boutoulout and Delfim F. M. Torres, the authors have discussed exact enlarged controllability for time fractional diffusion systems of the Riemann–Liouville type.

The paper "A Novel Four-Dimensional No-Equilibrium Hyper-Chaotic System With Grid Multiwing Hyper-Chaotic Hidden Attractors," by Sen Zhang, Yi Cheng Zeng, and Zhi Jun Li contains a novel four-dimensional no-equilibrium hyper-chaotic system with grid multiwing hyper-chaotic hidden attractor was presented.

In the paper "Dynamic Response of an Unbalanced Rigid Rotor Bearing System With a Nonlinear Hydrodynamic Force," by Chandan Kumar and Somnath Sarangi, the authors examine fixed point and periodic oscillations of a long journal bearing system. The paper "Design Optimisation Study of a Nonlinear Energy Absorber for Internal Combustion Engine Pistons," by N. Dolatabadi, S. Theodossiades and S. J. Rothberg, an alternative method that is robust to fluctuations in engine operating conditions has been discussed to improve the engine's NVH performance, while exacerbation in power loss remains within the limits of conventional methods.

In the paper "Analysis of Parametric Resonances in In-Plane Vibrations of Electrostrictive Hyperelastic Plates," by Astitva Tripathi and Anil K. Bajaj, the authors have studied a principal parametric resonance of the second mode in in-plane vibrations of appropriately designed electrostrictive plates. In the work "Analytical Solutions of Period-1 to Period-2 Motions in a Periodically Diffused Brusselator," by Albert C. J. Luo and Siyu Guo, analytical solutions of periodic evolutions of the periodically diffused Brusselator have been studied and stable and unstable solutions corresponding to period-1 and period-2 evolutions in the Brusselator were investigated.

In "Continuation Method on Cumulant Neglect Equations," by Edmond Perkins and Tim Fitzgerald, the authors have investigated the cumulant neglect equations, which are derived from the Fokker-Planck equation. In the paper "Heavy-Tailed Response of Structural Systems Subjected to Stochastic Excitation Containing Extreme Forcing Events," by Han Kyul Joo, Mustafa A. Mohamad, Themistoklis P. Sapsis, the authors have analyzed the complex, heavy-tailed probability distribution functions describing the response and its local extrema for structural systems subject to random forcing that including extreme events.

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