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Editorial

Special Issue "Application of Non-Linear Dynamics"

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Introduction

Nonlinear phenomena occur in engineering structures, biological systems, social processes, and in economics. Therefore, nonlinear problems are of interest to engineers, biologists, physicists, mathematicians, and many other scientists, because most systems are inherently nonlinear in nature. Nonlinear dynamic systems, which describe changes in variables over time, can seem chaotic, unpredictable, or counterintuitive compared to much simpler linear systems. In some cases, the nonlinear behavior of a system is desirable and could provide advantages, such as an increase in efficiency, stability, or control.

The collected works concern a wide range of issues related to nonlinear dynamics. However, several main topics of the accepted papers in this study can be distinguished. Many papers concern control problems [1–9], which is one of the most important and intensively developed branches of dynamics of mechanical and mechatronic systems. Purely mechanical systems are rarely found in modern technology, and hence electromechanical couplings occur in many works [1–3,9,10]. Another interesting area in this Special Issue deals with flow-induced vibration [4,11,12]. There are also works in which approximate analytical methods were used [4,10,13–15]. Due to the development of computer systems of symbolic transformation, asymptotic methods have gained much more importance in recent decades.

Let us briefly discuss the contents of each of the works. Germoso et al. [16] analyze soil mechanics. They indicate that the stress–strain relationship of soils is nonlinear and exhibits hysteresis. The proposed approach combines ingredients of modal and harmonic analyses, enabling the efficient time integration of nonlinear soil behaviors. Zhang et al. [17] adopted the harmonic balance and alternating frequency/time domain (HB–AFT) method in addition to Floquet theory to analyze the parametric resonances of varying compliance and their stabilities in rolling bearings. In the next paper, Olejnik et al. [1] study an adaptive tracking control of the speed of a very elastically attached circular load driven by a direct current motor accompanied by an adaptive conventional as well as a fractional-order proportional integral derivative (PID) controller. Wang et al. [11] investigate an aeroelastic system with freeplay. Its behaviors are visually represented using a method that combines a modified Poincaré map and the Lorenz map. Aroudi et al. [2] propose a discrete-time converter controller. This paper presents a study on the nonlinear dynamic behavior of a kind of capacitor. The results show that the system may undergo bifurcation phenomena and the period-doubling route to chaos when some system parameters are varied. Kulke et al. [13] investigate downhole drilling systems in which self-excited torsional vibrations are induced. The slim drill string design and the naturally limited drilled borehole diameter, as well as power supply, lead to numerous potentially critical torsional modes. The problem of seismic impact on water-heated channels is tested by Lee et al. [18]. A nonlinear dynamic model is developed to investigate the transient characteristics of the system. Paper [3], written by Aroudi et al., deals with the stability problem of a PV-fed differential boost inverter. The authors observe that the AC grid port might exhibit bifurcation phenomena

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under some weather conditions that lead to subharmonic oscillations. Lu et al. [12] consider the flutter boundary of a fin actuator system. The authors show that by changing the loads, material, and geometry of contact surfaces, flutter can effectively be suppressed and the power loss caused by friction can be minimized. Another article dealing with aerodynamic problems is that by Di Nino et al. [4]. Here, passive control of the nonlinear vibration of the resonant tower, exposed to turbulent wind flow, is employed. The multiple-scale method is adopted to solve the partial differential equations of motion. Critical and post-critical behaviors are investigated when two modes in an internal 1:3 resonance are involved in the response. Oborin et al. [19] apply a novel time integration technique to the nonlinear and linear dynamics of mechanical structures using an extended Picard-type iteration. Forced nonlinear vibrations of a tower-like mechanical structure, modeled by an inverted pendulum with a nonlinear restoring moment, are studied in this paper. The study of the differential transform method (DTM) used to integrate the Rössler system of fractional order is carried out by Rysak et al. [20]. It was shown that the bifurcation diagrams obtained by the DTM for the Rössler fractional system are more reliable compared to the RK4 scheme. In paper [21] (Wang et al.), the characteristics of softening/hardening stiffness of continuous and one-sided contact models with nonlinear springs are discussed. Here, the period-n solution branch and its stability characteristics are obtained through the harmonic balance and alternating frequency/time domain (HB–AFT) method using Floquet theory. The overall results may have certain basic theoretical significance and engineering values for the control of vibration and noise in contact mechanical systems. Another work on control issues was prepared by Rosinová et al. [5]. In the latter paper, the efficiency of a robust discrete time pole positioning controller for magnetic levitation systems is shown. In recent years, energy harvesting has become increasingly important for the application of mechanical vibrations in many devices. Paper [10] (Abohamer et al.) deals with this issue. This study investigates a dynamical system that correlates with two devices, namely a piezoelectric device and an electromagnetic one, to produce two novel models. Amer et al. [14] investigate the nonlinear dynamical motion of a double pendulum of two degrees of freedom with kinematic excitation. The importance of the model points to its applications in a wide range of fields, such as ship motion, swaying buildings, transportation devices, and rotor dynamics. The focus of paper [15] is on the investigation of a dynamical system consisting of a linear damped transverse tuned absorber connected with a nonlinear damped spring pendulum, in which its suspension point moves in an elliptic path. The last three articles [10,14,15] show the great usefulness of the asymptotic method of multiple scales. A very current problem is considered in [6] (Polcz et al.). A model of epidemic spread is considered, in which the vaccination process was taken into account. The applicability of the approach is illustrated through the estimation of the epidemiological data of the COVID-19 pandemic in Hungary. The next work [7] (Zhang et al.) concerns the computational methods of artificial intelligence. This research explores the effect of synaptic pruning on a ring-shaped neural network of nonlocally coupled FitzHugh–Nagumo (FHN) oscillators. Gosea [22] shows that, by means of exact and inexact lifting transformations, we can reformulate the original nonlinear dynamics into a different, more simplified format. The bilinear and quadratic bilinear systems accomplish precisely this goal. Xu et al. [8] develop a particle filter design scheme for a robust nonlinear control system of an uncertain heat exchange process against noise and communication delay. Particle weight adjustment can ensure the stability, tracking efficiency, and continuity of the particle filter control process. The stability of the periodic solution of rotor dynamics is analyzed by Hong et al. [23]. The authors show that an elastic stop is effective in suppressing vibration amplitudes if its stiffness has been properly designed. This study provides insight into dynamic responses and their applications to systems with gaps. Rotor dynamics is also considered by Saeed et al. [9]. Within their work, the radial proportional derivative (PD) controller, along with the eight-pole electromagnetic actuator, are introduced as a novel control strategy to suppress the lateral oscillations of a nonlinear Jeffcott rotor system.

In summarizing the discussions about the contents of the book, it is essential to highlight the diversity of the questions studied. All of the works included in this Special Issue have a common feature: a nonlinear mathematical model of the topics covered. This shows the extent and importance of nonlinear dynamics.

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