Preface to the special issue “NODYCON 2019”

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This special issue titled “NODYCON 2019” collects some of the most significant contributions presented at the First International Nonlinear Dynamics Conference in Rome, February 17–20, 2019.

NODYCON was conceived to foster the tradition of the illustrious conference series originally launched by Prof. A. H. Nayfeh in 1986 at Virginia Tech as the “Nonlinear Vibrations, Stability and Dynamics of Structures” Conference. NODYCON 2019 attracted a wide international community—400 participants from 68 countries—to share recent advances and discoveries in nonlinear dynamics research across different multi-disciplinary fields. NODYCON 2019 was also a tribute to NODY’s founding editor, Prof. Ali H. Nayfeh,

through the A. H. Nayfeh Prizes for the best student papers supported by Springer.

Out of 450 short papers submitted to NODYCON 2019, 391 papers and 17 posters were accepted and published in the conference Book of Abstracts. Nearly 10 % of the submitted papers (55 papers) were invited to this Special Issue and 42 were accepted for publication.

These papers reflect state-of-the-art results in the field of nonlinear dynamics. To provide a sound overview of the papers, they are grouped according to the following general topics and subtopics:

1. Mechanical systems

- a. Axially moving structures/loads*
- b. Rotating systems*
- c. Systems with friction*
- d. Energy flow*
- e. Waves*

2. Computational nonlinear dynamics

- a. Analytical methods*
- b. Numerical methods*

3. Bifurcation and control

- a. Bifurcation*
- b. Control*

4. New trends in nonlinear dynamics

- a. MEMS*
- b. Fractional-order systems*
- c. Biosystems dynamics*

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Mechanical systems

Several papers are devoted to the nonlinear dynamic analysis of broad classes of mechanical systems such as axially moving structures/loads, rotating beams and oscillators with friction. Moreover, attention is paid to analyzing energy flow problems and waves.

Axially moving structures/loads

Four papers deal with moving structures/loads. Two of them address: (i) an infinite Euler–Bernoulli beam resting on a nonlinear elastic foundation, or (ii) a taut string, both subjected to a traveling load. The remaining two papers analyze axially moving (i) beams or (ii) plates.

In the paper “Transition radiation in a piecewise linear and infinite one-dimensional structure—a Laplace transform method,” Andrei B. Faragau, Andrei V. Metrikine and Karel N. van Dalen present the one-dimensional model of an infinite Euler–Bernoulli beam resting on a locally inhomogeneous and nonlinear Winkler foundation, subject to a moving load. The model enables one to efficiently compute the beam response by sequentially applying the Laplace transform, combined with the finite difference method for spatial discretization. Non-reflective boundary conditions are derived, and the influence of the nonlinear behavior of the foundation on the generated waves is analyzed.

In the paper “Semi-analytical approaches for the nonlinear dynamics of a taut string subject to a moving load,” Manuel Ferretti, Giuseppe Piccardo and Angelo Luongo consider the loaded string problem using a novel coordinate transformation, based on the nonlinear quasi-static response. This approach, which is valid so long as the speed of the moving load is not too large, allows to unfold the strongly nonlinear dynamics in which the dynamic tension of the string can be up to twice as large as the static tension. This formulation provides accurate results for nonlinear string vibrations, using a relatively small number of eigenfunctions.

In the paper “Nonlinear vibration of axially moving beams with internal resonance, speed dependent tension and tension dependent speed,” You-Qi Tang and Zhao-Guang Ma formulate a new nonlinear model of axially accelerating viscoelastic beams, which allows for the analysis of parametric vibrations induced by time-dependent tensions or speeds. They use the method of multiple scales and the differential quadrature method to study vibrations when the beam under-

goes a 3:1 internal resonance. Different bifurcations are detected. The effects of the material viscoelastic properties, axial speed and tension fluctuation amplitudes are investigated.

In the paper “Parametric and internal resonance of a transporting plate with a varying tension,” Dengbo Zhang, Youqi Tang, Hu Ding and Liqun Chen deal with nonlinear transverse vibrations of in-plane accelerating viscoelastic plates, in presence of principal parametric and 3:1 internal resonances. The study shows that the natural frequency of the second mode is almost three times that of the first mode, such that a 3:1 internal resonance occurs. The study also reveals the effects of the viscous damping coefficient and the moving speed fluctuation amplitude on the stability of trivial and non-trivial solutions.

Rotating systems

Three papers study rotating systems, namely (i) a piezobeam, (ii) a predeformed blade under gas pressure and (iii) a vibro-impact rotating system.

In the paper “Nonlinear vibrations of a rotating thin-walled composite piezo-beam with circumferentially uniform stiffness,” Jaroslaw Latalski and Jerzy Warminski analyze a rotating system comprising a hub and a thin-walled laminate cantilever beam with embedded nonlinear piezoelectric transducers. A nonlinear analytical model of a piezoelectric material embedded into the beam walls is formulated considering higher-order constitutive relations which account for the electric field variable and the full two-way coupling piezoelectric effect. In particular, the influence of hub inertia, excitation amplitude and mean rotating speed on the system dynamics is investigated.

In the paper “Super-harmonic resonances of a rotating predeformed blade subjected to gas pressure,” Bo Zhang, Hu Ding and Li-Qun Chen investigate the dynamics of a rotating blade under pressure and subject to combined super-harmonic and 2:1 internal resonances. They consider both in- and out-of-plane rotations and account for the coupling between them. By using the method of multiple scales, the steady-state responses and their stability are investigated. The rotating speed is found to be responsible for transition from hardening to softening behavior. Several peculiar nonlinear phenomena, including jumps, hysteresis, saturation and intermittent chaos, are detected and confirmed through numerical results.

In the paper “Vibro-impact dynamics of two rolling heavy thin disks along a rotating curvilinear line and energy analysis,” Katica R. Hedrih presents a method for the construction of the phase portraits of a generalized rolling pendulum, containing two heavy thin disks rolling along a rotating curvilinear line and composed of three circle arcs. The paper gives the possible forms of the phase portraits with different structures of the sets of singular points and shows the energy transfer between the rolling disks in each of the series of successive collisions.

Systems with friction

Five papers are devoted to the dynamics of nonlinear systems with friction. One of them studies the slide-slip of a tire; the second paper addresses a single-degree-of-freedom mass in contact with an oscillating wall; the third paper illustrates an experimental study on friction-excited vibrations; the fourth paper tackles a drilling system with spatial friction; the fifth paper deals with vibration-driven locomotion based on stick-slip motions.

In the paper “Theoretical and experimental study on the nonlinear dynamics of wheel-shimmy,” Denes Takacs, Gergely Gyebroszki, Gabor Stepan and Sándor Beregi consider the dynamics of a model for a towed wheel with a delayed tire model and slide-slip in the tire contact area. The investigation of the resulting piecewise smooth, infinite dimensional system is carried out using numerical continuation methods to obtain periodic responses. Experimental results are presented, offering good qualitative comparisons with the model predictions.

In the paper “Displacement transmissibility of a Coulomb friction oscillator subject to joined base-wall motion,” Luca Marino, Alice Cicirello and David A. Hills focus on the displacement transmissibility of a single-degree-of-freedom system with a Coulomb friction contact between a mass and a fixed or oscillating wall. The paper proves the existence of an inversion point in the transmissibility curves, after which the friction damping amplifies the mass response. It describes the gradual disappearing of the resonant peak, when the ratio between friction and elastic forces increases. Moreover, it numerically detects the frequency region where mass sticking occurs in the base motion problem.

In the paper “Revealing transitions in friction-excited vibrations by nonlinear time-series analysis,” Merten Stender, Mariano Di Bartolomeo, Francesco

Massi and Norbert Hoffmann present an experimental study about the transitions in friction-induced vibrations in a highly sophisticated setup, where the relative motion is achieved by using air bearings and a voice-coil motor. The study reveals the existence of self-excited vibrations, period-1 and period-2 motions, quasi-periodic motions, weakly chaotic attractors and different types of stick-slip vibrations, as well as a sudden energy exchange between different modes and intermittent dynamics.

In the paper “Modeling and dynamic analysis of an anti-stall tool in a drilling system including spatial friction,” Roeland Wildemans, Arviandy Aribowo, Emmanuel Detournay and Nathan van de Wouw investigate the effects of a down-hole anti-stall tool in deviated wells on the drilling performance of a rotary drilling system, via a new dynamic model with coupled axial and torsional dynamics. The numerical analysis, based on the new model, shows that the rate-of-penetration and drilling efficiency increase by inclusion of the anti-stall tool, either with or without spatial Coulomb friction.

In the paper “Improving performance: recent progress on vibration-driven locomotion systems,” Jian Xu and Hongbin Fang present their recent studies on vibration-driven locomotion considering three main aspects: (1) dry friction-induced stick-slip motions analyzed and categorized based on the sliding bifurcation analysis; (2) bistability, a strong and global nonlinearity introduced into the internal oscillations with a broad frequency bandwidth for high average locomotion speed and multiple locomotion modes; (3) the planar locomotion capability achieved by incorporating two internal oscillators in the system.

Energy flow

Two papers are devoted to energy flow problems. One deals with energy absorbers, the second with a chain of oscillators.

In the paper “Stochastic energy absorbers based on analogies with soft wall billiards,” Valery Pilipchuk introduces a finite-degree-of-freedom Hamiltonian model exhibiting one-directional long-term trends in energy exchange flows. The model includes a massive potential well—a container with one or a few light non-interacting particles—attached to a linearly elastic spring. In particular, the conditions for stochasticity of the model dynamics, based on the nonlinear normal mode stability concept, are presented. Finally, possi-

ble applications to macro-level energy harvesters and the design of artificial energy absorbing materials are discussed.

In the paper “Unidirectional energy transport in the symmetric system of nonlinearly coupled oscillators and oscillatory chains,” Gil Yacobi, Victor Kislovsky, Margarita Kovaleva and Yuli Starosvetsky study the mechanism of unidirectional energy transport in a symmetric, weakly dissipative, system of two coupled nonlinear oscillators and weakly coupled oscillatory chains. The paper proves that the system allows the irreversible transfer of energy from the initially excited oscillator to the initially resting one and shows the control mechanism of spatially localized nonlinear waves in weakly dissipative, coupled oscillatory chains.

Waves

Two papers study the propagation of waves in a one-dimensional metamaterial or in multiple-dimension tensegrity beams.

In the paper “Wave propagation properties of one-dimensional acoustic metamaterials with nonlinear diatomic microstructure,” Marco Lepidi and Andrea Bacigalupo consider a one-dimensional diatomic lattice model with cubic nearest-neighbor coupling. The linearized dynamics of this system are used as a basis for the analysis of the weakly nonlinear system, using the method of multiple scales. Nonlinear dispersion relations and waveforms for nonresonant and 3:1 internally resonant cases are derived, and specific examples are used to elucidate the general features of these systems.

In the paper “On the compact wave dynamics of tensegrity beams in multiple dimensions,” Andrea Micheletti, Giuseppe Ruscica and Fernando Fraternali present numerical investigations into the nonlinear wave dynamics of tensegrity beams with 1D, 2D and 3D arrangements. The numerical results relevant to 2D and 3D beams reveal the presence of compact compression waves in two- and three-dimensional tensegrity lattices with slender aspect ratio and stiffening-type elastic response. The analyzed behaviors suggest the use of multidimensional tensegrity lattices for the design and additive manufacturing of novel sound focusing devices.

Computational nonlinear dynamics

Papers in this group introduce new algorithms, as well new versions of classical methods, aimed to ana-

lyze general nonlinear systems dynamics. Both analytical and numerical methods, sometimes combined, are addressed.

Analytical methods

Three papers describe analytical tools for nonlinear dynamic analysis. The first uses spectral submanifolds, which can also detect isolas; the second illustrates mathematical tools for studying escape from potential wells and the third compares different methods for forced responses.

In the paper “Analytic prediction of isolated forced response curves from spectral submanifolds,” Sten Ponsioen, Tiemo Pedergnana and George Haller describe the use of spectral submanifolds to analyze the response of multi-degree-of-freedom systems subject to time-periodic forcing. A special feature of this approach is that it provides an explicit criterion for the existence of isolas. The results are illustrated by means of archetypal systems with both low and high numbers of degrees of freedom.

In the paper titled “Basic mechanisms of escape of a harmonically forced classical particle from a potential well,” Oleg Gendelman and Gleb Karmi perform an exploration of the transient dynamics of the escape in a number of benchmark potential wells. They explain why the minimal force amplitude required for the escape exhibits a sharp minimum for the excitation frequency below the natural frequency of small oscillations. Essentially, the nonlinear model requires transformation to action-angle variables and demonstrates very similar qualitative features of the transient dynamics, including two competing scenarios of the escape transition.

In the paper “Using frequency detuning to compare analytical approximations for forced responses,” Alexander J Elliott, Andrea Cammarano, Simon A Neild, Thomas L Hill and David J Wagg carry out a comparison of three techniques for analyzing the forced response of nonlinear vibration systems: harmonic balance, multiple scales and normal forms. Using frequency detuning as a basis for comparing results from the three approaches, they show that, under suitable conditions, all three methods yield the same solutions.

Numerical methods

Six papers discuss new numerical methods for nonlinear dynamic analysis. One is devoted to numerical continuation methods, robust to experimental noise;

the second to asymptotic numerical methods, able to compute bifurcation diagrams; the third proposes sophisticated finite elements for finite displacements in the elastoplastic regime; the fourth introduces a rate-independent phenomenological model to study non-stiffening hysteretic systems; the fifth presents a data-driven model for chaotic systems; the sixth discusses new algorithms for a class of nonlinear systems in presence of unknown noise.

In the paper “Numerical continuation in nonlinear experiments using local Gaussian process regression”, L. Renson, J. Sieber, D. A.W. Barton, A.D. Shaw, S.A. Neild combine the control-based continuation (CBC), which is a general and systematic method to probe the dynamics of nonlinear experiments, with a novel continuation algorithm, that is robust to experimental noise and enables the tracking of the geometric features of the response surface. A novel aspect of the proposed method is a separate data collection step, which selects input values maximizing information about the dynamic features of interest. The method is demonstrated experimentally on a nonlinear structure featuring harmonically-coupled modes.

In the paper “A Taylor series based continuation method for solutions of dynamical systems,” Louis Guillot, Bruno Cochelin and Christophe Vergez present a so-called asymptotic numerical method, a generic Taylor series based continuation method, to compute the bifurcation diagrams of nonlinear systems. The key point of the method is the quadratic recast of the equations as this enables one to compute the periodic and quasi-periodic motions of a wide range of dynamic systems, possibly with time-delays or fractional-order derivatives, in the same framework.

In the paper “Nonlinear oscillations and dynamic stability of an elastoplastic pyramidal truss,” Murillo V. B. Santana, Paulo Batista Gonçalves and Ricardo A. M. Silveira use a corotational finite element formulation to study large amplitude motions of trusses composed of elastoplastic elements. The study considers finite static configurations of the truss that sets the stage for its dynamic response which can be periodic, quasi-periodic or chaotic under harmonic excitations. The effects of material parameters, truss geometry and loading conditions are investigated via parametric analyses, with a particular emphasis on the role played by strain-hardening.

In the paper “Nonlinear dynamic analysis of hysteretic mechanical systems by combining a novel rate-

independent model and an explicit time integration method,” Nicolò Vaiana, Salvatore Sessa, Francesco Marmo and Luciano Rosati present a computational strategy for nonlinear dynamic analyses of non-stiffening hysteretic mechanical systems. This combines a novel rate-independent phenomenological model with an explicit time integration method. The procedure is validated, for specific problems, by comparing it with the popular Newmark numerical method and the Bouc–Wen rheological model. It is shown that the computational burden required by the proposed strategy is significantly reduced.

In the paper “Neural machine based forecasting of chaotic dynamics”, Rui Wang, Eugenia Kalnay and Balakumar Balachandran (winner of the first A. H. Nayfeh Prize) explore an alternate modeling approach, which is based on data-driven modeling, to explore forecasting viability for systems that display chaotic dynamics. Specifically, a deep recurrent neural network architecture is constructed for forecasting temporal evolution of different chaotic systems.

In the paper “A novel two-stage ellipsoid filtering based system modeling algorithm for a Hammerstein nonlinear model with an unknown noise term,” Ziyun Wang, Ze Tang and Ju H. Park deal with the system modeling problem for the Hammerstein nonlinear model, with unknown but bounded noise. The paper presents a modeling algorithm based on two-stage ellipsoid filtering and illustrates the feasible parameter set variation process and the motion trail of the ellipsoids, which shows the effectiveness and the accuracy of the proposed algorithm.

Bifurcation and control

A few papers deal with bifurcation analysis of pipes conveying fluid, non-smooth and delayed systems. The topic of control in the context of bifurcation analysis is also tackled.

Bifurcation

Three papers tackle bifurcation problems. One of them studies modal interactions in pipes conveying fluid, experiencing double Hopf bifurcations; a second paper analyzes period-doubling bifurcations in oscillators with clearances; the third paper deals with bifurcations in delayed equations modeling machine tool vibrations.

In the paper “Nonlinear interactions between unstable oscillatory modes in a cantilevered pipe conveying fluid,” Kiyotaka Yamashita, Takahiro Yagyu and

Hiroshi Yabuno study the dynamics of systems experiencing a double Hopf bifurcation. The considered system is a pipe conveying fluid for which the second and third modes can become unstable. Their analysis of the governing equations shows that while the two modes can become individually self-excited, mixed mode self-excitation is inhibited. Results presented from an experimental study demonstrate a qualitative agreement with the theory.

In the paper “Period doubling bifurcation analysis and isolated sub-harmonic resonances in an oscillator with asymmetric clearances,” Sébastien Baguet, Benoit Prabel, Philippe Piteau, Georges Jacquet-Richardet and Roberto Alcorta use harmonic balance and continuation techniques for a frequency domain analysis of the systems of interest. The method allows for efficient and thorough two-parameter studies which accurately predict bifurcation conditions and extrema of the response curves. The study provides an accurate characterization for a wide range of dynamic behaviors that includes period-doubling cascades and the appearance of isolas.

In the paper “Bifurcation analysis of a forced delay equation for machine tool vibrations,” Janos Lelkes and Tamas Kalmar-Nagy investigate the classical one-degree-of-freedom, tool vibration model described by a delay-differential equation with both quadratic and cubic nonlinearities. The paper presents the stability and bifurcation analysis of equilibrium points of the slow flow equations, revealing abundant nonlinear dynamics, such as the sub-critical and super-critical Hopf bifurcations, the generalized Hopf (Bautin) bifurcations and the Bogdanov–Takens bifurcations.

Control

Five papers are devoted to control strategies. The first one discusses intermittent control aimed to expand the stable region in parameters space; the second paper addresses control of imperfect systems using chaotic vibrational signals; the third one analyzes position control using discrete-time state-feedback; the fourth paper proposes feed-forward control for self-sustained oscillators; the last paper investigates passive control of a non-smooth absorber.

In the paper “Estimation and improvement of cutting safety,” Yao Yan, Jian Xu and Marian Wierciroch analyze the stability of cutting dynamics and the use of intermittent controls to expand the zone of stable operating parameters. The authors consider basins of attraction for their stability analysis in order to

account for regions of bistability, in which stable operation and chatter co-exist. They show how various control strategies, including velocity feedback and spindle speed variation, can improve operation by enlarging the basins that correspond to stable cutting.

In the paper “Control of imperfect dynamical systems,” Maide Bucolo, Arturo Buscarino, Carlo Famoso, Luigi Fortuna and Mattia Frasca focus on a complex and imperfect electromechanical structure that can be considered as a paradigm for imperfect systems and investigate the performance of a novel control strategy of the system. The latter is based on taking advantage of the unavoidable imperfections, associated to physical realizations, by stimulating the hidden dynamics associated with them. Under these conditions, an overall improvement in the system performance can be clearly observed. In particular, the effect of using chaotic vibrational signals to excite the hidden dynamics of the imperfect system is studied.

In the paper “Combined effects of sampling and dry friction on position control,” Csaba Budai, László L. Kovács, József Kövecses, Gabor Stépán study the combined effects of sampling and dry friction on the dynamics of mechanical systems subjected to position control using discrete-time state-feedback. For the analysis of the effect of sampling with dry friction, a detailed analysis is presented for the frictionless system. It is demonstrated that even a single-degree-of-freedom mechanical system can exhibit multi-frequency vibrations when it is positioned by a discrete-time state-feedback controller. The observed vibrations can be explained by the higher harmonics in the solution which correspond to the periodicity of the eigenvalues of the transition matrix.

In the paper “Enforcing synchronization in oscillators with Huygens’ coupling via feed-forward control,” Jonatan Pena Ramirez and Henk Nijmeijer study a synchronization strategy based on a feed-forward controller for self-sustained oscillators interacting via Huygens’ coupling. Two particular examples are considered: a modified version of the classical Huygens’ system of pendulum clocks coupled through a common bar and a pair of self-sustained mass-spring-damper oscillators mounted on a suspended bar. A formal analysis of the controlled system is conducted by using the Poincaré method of perturbation. The analysis reveals that the proposed feed-forward controller may enforce the desired synchronous motion provided that some

intrinsic parameters of the pendula satisfy certain conditions.

In the paper “Passive control of a two degrees-of-freedom pendulum by a non-smooth absorber,” Gabriel Hurel, Alireza T. Savadkoobi and Claude-Henri Lamarque deal with the forced vibration of a two-degree-of-freedom pendulum with a non-smooth absorber attached at an arbitrary location and orientation. By using the method of multiple scales, the authors investigate the topology of the slow invariant manifold and study the vibration reduction of the pendulum in terms of the excitation frequency, together with the efficiency of the non-smooth absorber in several case studies.

New trends in nonlinear dynamics

New trends in nonlinear dynamics are also discussed in this Special Issue, namely: (i) micro electromechanical systems (MEMS), (ii) fractional-order systems and (iii) biosystems dynamics.

MEMS

Four papers deal with MEMS. The first studies networks of self-excited MEMS, synchronized under various coupling conditions; the second paper analyzes parametrically excited micro-beams, used as flow sensors; the third paper investigates arrays of elastically coupled microcantilever beams under electrodynamic excitation; the fourth papers deal with carbon nanotube resonators under parametric resonance.

In the paper “Synchronization in a network of coupled MEMS-Colpitts oscillators,” Scott T. Habermehl, Nikhil Bajaj, Shreyas Shah, D. Dane Quinn, Dana Weinstein and Jeffrey Rhoads describe an experimental study of a network of three coupled MEMS-based self-excited oscillators. A variety of coupling conditions and oscillator frequencies are considered, for the control of frequency synchronization and relative phase conditions. The study demonstrates the rich dynamics of the coupled oscillators and highlights potential applications in areas such as neuromorphic computing and pattern recognition.

In the paper “Micro-beam resonator parametrically excited by electro-thermal Joule’s heating and its use as a flow sensor,” Ben Torteman, Yoav Kessler, Alexander Liberzon and Slava Krylov investigate the parametric resonance of doubly clamped micro-beams that are electro-thermally actuated by time-dependent Joule heating and cooled by a steady air flow. An analytical formulation of the Mathieu-Duffing equation describ-

ing the beam’s vibrations, due to the time-harmonic compressive force, is presented. The limitations arising from the requirements on the excitation frequency and amplitude are analyzed. It is shown that parametric resonance will always occur at the values of the compression force which are lower than the static buckling force. Finally, two solutions allowing to overcome the intrinsic limitation arising from the DC component responsible for static buckling are presented.

In the paper “Nonlinear multi-element interactions in an elastically coupled microcantilever array subject to electrodynamic excitation,” Prashant N Kam-bali, Francesc Torres, Nuria Barniol and Oded Gottlieb formulate and investigate a nonlinear initial-boundary-value problem for an array of N elastically coupled hybrid microcantilever beams subject to electrodynamic excitation. The Galerkin method is used to obtain a nonlinear modal dynamical system that consistently incorporates a quintic nonlinearity, due to the combined effects of cubic viscoelasticity and quadratic electro-dynamics. It is noteworthy that an array with a larger coupling stiffness, corresponding to a smaller distance between adjacent elements, yields a chaotic bifurcation structure for a larger value of viscoelastic damping.

In the paper “Voltage effect on frequency response of parametric resonance of electrostatically actuated double wall carbon nanotube resonators,” Dumitru I. Caruntu and Ezequiel Juarez deal with the amplitude-frequency response of coaxial parametric resonance of electrostatically actuated double-walled carbon nanotubes, via the reduced order model of Euler–Bernoulli beams. The paper presents the effects of voltage and damping on the frequency-amplitude response of the electrostatically actuated double-walled carbon nanotubes and shows that an increase in voltage or a decrease in damping results in a wider frequency range for which pull-in occurs.

Fractional-order systems

Three papers deal with fractional-order systems. One of the papers discusses harmonically excited hysteretic oscillators with different constitutive properties; another paper is focused on electrolytic capacitors for electronics applications; the third paper is devoted to piezoelectric actuators exhibiting broadband hysteresis.

In the paper “Steady-state dynamic response of various hysteretic systems endowed with fractional derivative elements”, Pol D. Spanos, Alberto Di Matteo and

Antonina Pirrotta examine the harmonically excited, steady-state dynamic response of hysteretic oscillators, comprising fractional derivative elements. The amplitude of the steady-state response is determined analytically by using an equivalent linearization approach. Various models of hysteresis, including the bilinear, Bouc–Wen and Preisach models, are reported together with parametric studies.

In the paper “Fractional techniques to characterize non-solid aluminum electrolytic capacitors for power electronics applications,” Xi Chen, Lei Xi, Yunning Zhang, Hui Ma, Yuehua Huang and Yangquan Chen study the frequency-dependent parameter shift of non-solid aluminum electrolytic capacitors. Two fractional-order equivalent circuit models are proposed, and an error optimization scheme, based on differential evolution algorithm, is presented for parameter identification of the two proposed models. To show further applications of fractional techniques, a brief example on the output ripple analysis of DC-DC converters is offered, in which one of the proposed fractional-order models of the capacitor is adopted.

In the paper “Fractional-order model and experimental verification for broadband hysteresis in piezoelectric actuators,” Changshun Ding, Junyi Cao and YangQuan Chen propose fractional-order model methods to describe broadband hysteresis of piezoelectric actuators. The model is utilized to describe the relationship between the input voltage and the output displacement of a piezoelectric actuator. Different experiments in the time and frequency domains are performed to verify the effectiveness of the proposed methods. The fractional order model identified in the frequency domain is helpful for precise modeling and control of nonlinear rate-dependent hysteresis in piezoelectric actuators.

Biosystems dynamics

Biosystems dynamics is the topic of the last two papers. One of them studies a self-propelled capsule traveling across a small intestine; the other paper investigates human and animal DNA by using a fractional approach.

In the paper “Modelling of capsule-intestine contact for a self-propelled capsule robot via experimental and numerical investigation,” Bingyong Guo, Yang Liu and Shyam Prasad model the capsule-intestine contact through experimental and numerical investigation. The goal is to design a self-propelled capsule robot moving inside the small intestine for endoscopic diagnosis. The work is aimed to sharpen our understanding of capsule-intestine interactions, in order to design a robust control strategy or an efficient locomotion mechanism for stabilizing the self-propelled capsule robot in the small intestine.

In the paper “Information analysis of the human DNA,” J. Tenreiro Machado proposes a scheme for reading the information of each Chr code and translating it into a state space trajectory. It is verified that the fractional approach leads to a superior discrimination of the information embedded in the 2-dimensional locus. The dataset is further explored through Jensen–Shannon divergence and multidimensional scaling. The proposed approach is first applied to the 24 human chromosomes. In a second phase Bonobo, Chimpanzee and Orangutan DNA are also considered for establishing a comparison between the four species.

Conclusions

This special issue offers an extensive overview of current research in the broad field of Nonlinear Dynamics, ranging from revisited classical problems to emerging topics, in Mechanics as well in other disciplines crossing the traditional boundaries, with special attention to increasingly efficient algorithms.

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