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Jan Awrejcewicz *Editor*

Perspectives in Dynamical Systems I: Mechatronics and Life Sciences

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Editor
Jan Awrejcewicz
Department of Automation, Biomechanics
and Mechatronics
Lodz University of Technology
Lodz, Poland

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Preface

15th International Conference "Dynamical Systems – Theory and Applications" (DSTA 2019) took place in Lodz, Poland from the 2nd to 5th December of 2019. It was the 15th edition in the series of conferences organized every 2 years in Lodz by the Department of Automation, Biomechanics and Mechatronics of the Lodz University of Technology.

For this edition, the scientific committee composed of 64 scientists had to review over 360 submitted topics to choose 200 that were to be presented during the DSTA 2019 by participants representing 40 countries from all over the world.

It resulted in the program of conference that covered both theoretical and experimental approaches to widely understood dynamical systems, including topics devoted to bifurcations and chaos, control in dynamical systems, asymptotic methods in nonlinear dynamics, stability of dynamical systems, lumped mass and continuous systems vibrations, original numerical methods of vibration analysis, nonsmooth systems, dynamics in life sciences and bioengineering, as well as to the engineering systems and differential equations.

All papers included in the following book were submitted and presented during DSTA 2019. They contribute partially to the diverse approaches and topics covered by wide scope of dynamical systems.

In what follows a brief description of the book content is provided.

In Chap. 1, authors utilized Lagrange's principles and multiple scale technique to obtain governing equations of the vibrating motion of a cylinder over circular surface under the influence of an exciting force and its asymptotic solutions using Routh-Hurwitz criterion for systems stability determination.

Mykulyak and Skurativskyi (Chap. 2) considered problem of the system dynamics, when the friction is incorporated and the harmonic force is applied to the most upper level of the system. The bifurcations with respect to the structural parameter were investigated for the periodic, quasiperiodic and chaotic attractors regimes revealed by application of the numerical and qualitative analysis methods.

Awrejcewicz et al. (Chap. 3) constructed the mathematical model of the nonlinear dynamics of flexible mesh cylindrical panels in the field of additive white noise taking into account a Cosserat medium. Model obtained applying Pshenichniy

continuum model and Kirchhoff-Love hypotheses was used to prove that the noise with intensity commensurate with the intensity of the normal load does not change oscillations character of the system.

A method for measuring the motion trajectory of a vehicle as well as results of computer simulation tests of the control system, which involves individual braking of one, two or three wheels of the vehicle in order to improve its directional stability are presented in Chap. 4.

Kim et al. (Chap. 5) studied nonlinear phenomenon through the experiments and the frequency response curves. Their research proved possibility of the occurrence of the super-harmonic resonance when the excitation frequency is three times of the natural one by performing experimental investigations.

Methodology for the development of a dynamic test bench is presented by Siqueira et al. (Chap. 6). For this purpose the commonly applied for high speed kinematic systems delta-robot configuration was adapted in a way to allow application of high transverse loads in three axis while keeping a considerably large range of movement.

Finite difference model of a robust universal heat exchanger applicable for prediction of the heat exchanger dynamics for condenser at normal operation level was developed by Zamojski et al. (Chap. 7). The carried out analysis included simulation and control design of multiphase fluid dynamics of an existing heat pump.

Mathematical approach to assess a human gait is proposed in Chap. 8. Modelling of a normal gait in sagittal and frontal anatomical planes of the body using Newton-Euler formulation yielded three multibody biomechanical models that can be used to model a single support phase and double support phase of the gait.

Carvalho and Pinto (Chap. 9) proposed a non-integer order model to describe the role of the immune system in cancer cells' growth in a HIV-infected individual. By considedratuon of the various orders for the fractional derivative the model for different values of biologically relevant parameters is simulated yielding biologically relevant results.

Using the vibrissae of rats as the model of mechanoreceptors Scharff (Chap. 10) investigated how an artificial vibrissa-like tactile sensor interacts with an object contour that is superimposed with macroscopic features. Simulation for a straight horizontal contour with superimposed sinus undulation was validated experimentally using a wavy contour with superimposed macroscopic features.

Grzelczyk et al. (Chap. 11) proposed and experimentally validated a design of lower limb exoskeleton driven by linear electric actuators. A new gait generator, which can be used to produce rhythmic movements in hip and knee joints of both limbs, was developed and tested using the time histories of human joint angles in normal gait as an articulation variables of individual joints of the investigated device.

Recorded dynamic variables of hexapod walker robots gait scenarios were used by Kecskés et al. (Chap. 12) for analyses of the model uncertainties. Five different methods were applied for both quantification and evaluation of the experimentally obtained results yielding important information for the robust control design research.

Augustynek and Urbaś (Chap. 13) proposed model of the revolute joint with the clearance for analysis of the linkage composed of the five rigid or flexible links which form a serial closed-loop kinematic chain. Applied numerical simulations allowed to investigate an interaction between the links' flexibility and clearance in the joint during the motion of the linkage.

In Chap. 14, Harlecki et al. present developed mathematical model for analysis of the truck with a trailer combination of vehicles. Model constituting it as a multibody system, for using formalism of Lagrange's equations, based on the joint coordinates and homogeneous transformations taken from robotics, can be treated as a virtual prototype of the system in question with application in truck trailers design.

Martowicz et al. (Chap. 15) applied artificial neural networks to simulate and experimentally identify complex behavior of the shape memory alloys type of smart materials. The constitutive models allowed to reliably model the hysteretic character of the stress-strain relationship observed for the experimentally tested material.

Chapter 16 is devoted to the synthesis of a mathematical model of the electrohydraulic servo-drive taking into account such nonlinearities as friction model, characteristics of the modulus of the elasticity, dependence of flow intensity on pressure drop at control edges of the valve slide, dependence of hydrodynamic force, and characteristics of the volumetric loss factor in the pump. Proposed model was experimentally through comparison with results obtained for real electrohydraulic servo-drive and can be used in fast prototyping of the nonlinear state-space control systems.

In Chap. 17, comparison of the performance of payload weighing systems involving neural networks is proposed. Kosiara et al. discussed also possibility of replacing the conventional models implemented in the most up to date payload weighing systems with the ones based on the neural networks and influence of training dataset size on the accuracy of the systems.

Stańczyk et al. (Chap. 18) studied degrees of freedom (DOFs), kinematics and drive systems of available constructions of lower limb exoskeletons. Results of those comparative analyses were used to design and construct a lower limb and spine exoskeleton that can be applied in gait rehabilitation of patients suffering from different mobility impairments.

Chapter 19 deals with the theory of solution of transverse shock wave propagation in thin plane elastic isotropic plate. Presented are both analytical solutions of transverse displacement, velocity and stress for various material and geometric models of the plate, as well as results of their experimental validation.

Cherkasov and Makieva in Chap. 20 proposed application of the Pontryagin maximum principle as a method of reduction of the optimal control problem to a boundary value problem for the initial variables in the classical differential game theory. Analyzed was the two-dimensional pursuit-evasion problem for the case of proportional navigation of the unmanned aerial vehicle.

Method of optimization of the geometry of aeroelastic energy harvester using a genetic algorithm that processes data from computational fluid dynamics calculations is proposed in Chap. 21. Results generated by applied algorithm to maximize

the efficiency of the device were experimentally validated, and their efficiency was then compared with that of commonly used resonator implemented in the aeroelastic energy harvester.

Hedrih (Chap. 22) studied rolling homogeneous heavy ball over the surface with arbitrary shape, in the real Rn3 space. Proposed new methodology allowed to determine the current angular velocity of rolling the ball over the surface in the function of generalized coordinates and their direction using the velocity vector of the center of the ball.

In Chap. 23, results of applying the methodology of hyperbolic-elliptic models for surface wave field to the case of a half-space coated by a vertically inhomogeneous layer are presented. The study was focused on surface waves propagating in an isotropic elastic half-space coated with a thin, vertically inhomogeneous layer, subject to action of a prescribed normal surface stress.

Behn et al. (Chap. 24) analyzed eigenvalues in the first octant of the complex plane for two models of boundary damping for vibrissa-like sensors and focusing on bending beam vibrations. During their studies, authors found two systems with complementary spectra of eigenvalues that have alternative instead of common eigenvalues.

DSTA Conferences are aimed to provide a common platform for exchange of new ideas and results of recent research in the field of scientific and technological advances in modern dynamical systems. Over the last 25 years both approaches and understanding of sciences significantly evolved to include new ideas and trends, but the traditional views are still present and provide the basic understanding. Therefore, both as Head of Organizing and Scientific Committees of DSTA 2019 and as the Editor of volume of Springer Proceedings, I hope that this book will provide the readers with both answers to their problems and ideas for their novel approaches to study nonlinear dynamical systems.

I greatly appreciate the help of Springer Editor Dahlia Fisch, Springer Project Coordinators Murugesan Tamilsevan and Saveetha Balasundaram as well as T. Metilda Nancy Marie Rayan, the project manager at Straive – in publishing this volume in the Springer Proceedings in Mathematics and Statistics series. I would like also to express my gratitude to Scientific Committee of DSTA 2019 and all reviewers for their help and professional support during the book preparation.

Łódź, Poland Jan Awrejcewicz

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