

# Preface

The international conference, “Dynamical Systems—Theory and Applications” (DSTA), held during 7–10 December 2015 in Lodz (Poland), has been the 13th edition of a conference series with a 23-year history. This scientific meeting organized by the Department of Automation, Biomechanics and Mechatronics of the Lodz University of Technology aims at providing a common platform for the exchange of new ideas and results of recent research and the scientific and technological advances of the field as well as modern dynamical system achievements. The scope of the conference covered the following topics: bifurcations and chaos, control in dynamical systems, asymptotic methods in nonlinear dynamics, stability of dynamical systems, lumped and continuous systems vibrations, original numerical methods of vibration analysis, non-smooth systems, dynamics in life sciences and bioengineering, engineering systems and differential equations, and mathematical approaches to dynamical systems.

All topics discussed in this book were covered by participants of the last edition of the DSTA conference. However, only a small part of different approaches and understandings of dynamical systems is presented in this book. In what follows, a brief description of results of theoretical, numerical and experimental investigations conducted by researchers representing different fields of science is given. While at the first sight they seem to be very diverse, they all are linked by the common factor, i.e. dynamical systems.

Chapter “[Bifurcation and Stability at Finite and Infinite Degrees of Freedom](#)” deals with problems of bifurcation and stability while modelling mechanical systems having finite and infinite degrees of freedom. Spectra of linear operators, Lyapunov–Schmidt and Centre Manifolds reduction are employed, among others.

The problem of reduction of low-frequency acoustical resonances inside a bounded space with an acoustical source is solved by Błażejowski (Chap. “[Reduction of Low Frequency Acoustical Resonances Inside Bounded Space Using Eigenvalue Problem Solutions and Topology Optimization](#)”) using eigenvalue problem solutions matched with topology optimization.

Chapter “[Analysis of the Macro Fiber Composite Characteristics for Energy Harvesting Efficiency](#)” is aimed at an analysis of the macro-fiber composite characteristics for energy harvesting efficiency. Maximization of the root mean square of output electrical power is illustrated, and a composition of the system dynamics at optimized load resistance levels is carried out. The proposed approach is simulated with the use of the finite elements method and then experimentally validated.

Bučinskas et al. (Chap. “[Research of Modified Mechanical Sensor of Atomic Force Microscope](#)”) present the method resulting in speed increase in nano-scale surface scanning by adding nonlinear force to lever of mechanical sensor. Comparison of the results of both original and modified atomic force microscope scans is also discussed.

Nonlinear dynamics of the car driving system with a sequential manual transmission is investigated in Chap. “[Nonlinear Dynamics of the Car Driving System with a Sequential Manual Transmission](#)”. A complex computational model of a car sequential gearbox is constructed and the study of the nonlinear behavior of the whole driving system has been performed.

Dynamics of von Kármán plates under multiplicative white noise loading is analysed in Chap. “[Random Attractors for Von Karman Plates Subjected to Multiplicative White Noise Loadings](#)”. The existence of random attractors is proved using the estimation of the system energy function.

Chmielewski et al. (Chap. “[The Use of Fuzzy Logic in the Control of an Inverted Pendulum](#)”) describe the fuzzy logic control of an inverted pendulum. The problem is reduced to a study of a system with two degrees of freedom by means of force extortion of the corresponding carriage displacement.

Drag (Chap. “[Artificial Neural Network for Stabilization of the Flexible Rope Submerged in Sea Water](#)”) has employed an artificial neural network for the stabilization of a flexible rope submerged in the seawater. The influence of the sea environment, the vessel velocity and the lumped mass of the rope end is studied.

Chapter “[Analysis of Non-autonomous Linear ODE Systems in Bifurcation Problems via Lie Group Geometric Numerical Integrators](#)” aims at a bifurcation analysis using the Lie group geometric numerical integrators. In particular, the importance of the Magnus method in studying certain paradigmatic bifurcation problems is addressed.

Chapter “[Transient Vibrations of a Simply Supported Viscoelastic Beam of a Fractional Derivative Type Under the Transient Motion of the Supports](#)” deals with transient vibrations of a simply supported viscoelastic beam under the transient motion of the supports. Both the Riemann–Liouville fractional derivative and the fractional Green’s functions are applied and shown that the proposed procedure widens the classical methods aimed at damping modelling of structural elements.

Gapiński and Koruba (Chap. “[Analysis of Reachability Areas of a Manoeuvring Air Target by a Modified Maritime Missile-Artillery System ZU-23-2MRE](#)”) have analysed the reachability areas of maneuvering air targets achieved by a modified maritime missile-artillery system. In particular, the starting zone and the zone of destination for the particular air-defence fire unit are determined.

In Chap. “[Angular Velocity and Intensity Change of the Basic Vectors of Position Vector Tangent Space of a Material System Kinetic Point—Four Examples](#)” the angular velocity and the intensity of basic vectors change of position vector tangent space of a material system kinetic point are studied.

In Chap. “[Dynamics of Impacts and Collisions of the Rolling Balls](#)” the theory of dynamics of impacts and collisions of rolling balls are introduced, including various balls configurations. Different ball rolling traces before/after each type of impact/collision are illustrated, and kinematic parameters of impact and corresponding translational and angular velocities are presented.

Approximated analytical solutions to the Jerk equations are derived in Chap. “[Approximate Analytical Solutions to Jerk Equations](#)”. The obtained third-order nonlinear differential equations can govern structures performing rotational and translational motions of robots and machine tools.

A simple model of the Chandler wobble is studied from a point of view of stochastic and deterministic dynamics in Chap. “[Chandler Wobble: Stochastic and Deterministic Dynamics](#)”. The investigations refer to the Earth’s torqueless precession with a period of about fourteen months.

Chapter “[Impact of Varying Excitation Frequency on the Behaviour of 2-DoF Mechanical System with Stick-Slip Vibrations](#)” presents results of investigation of a varying excitation frequency on the behaviour of two degree-of-freedom system with stick-slip vibrations. A mathematical model of a block-on-belt system with normal force intensification mechanism and the model of a DC motor with worm gear are studied with a special attention paid to the bifurcation phenomena.

In Chap. “[An Analysis of the 1/2 Superharmonic Contact Resonance](#)” nonlinear normal contact vibrations of two bodies are studied. Many interesting nonlinear phenomena including loss of contact, multistability, period doubling bifurcations as well as the superharmonic contact resonances are illustrated and discussed.

The optimal variational method is employed in Chap. “[The Oscillator with Linear and Cubic Elastic Restoring Force and Quadratic Damping](#)” to study dynamics of simple oscillators with linear and cubic elastic restoring force and quadratic damping. Excellent agreement between analytical and numerical results is obtained.

The wave-based control to suppress vibrations during re-positioning of a flexible robotic arm on a planetary rover in a Martian environment is employed in Chap. “[Wave-Based Control of a Mass-Restricted Robotic Arm For a Planetary Rover](#)”. The applied controller has performed well in limiting the effects of the flexibility during manoeuvres and in resisting vibrations caused by impacts.

Soft suppression of traveling localized vibrations in medium-length thin sandwich-like cylindrical shells containing magnetorheological layers is investigated in Chap. “[Soft Suppression of Traveling Localized Vibrations in Medium-Length Thin Sandwich-Like Cylindrical Shells Containing Magnetorheological Layers via Nonstationary Magnetic Field](#)”. The derived differential equations with coefficients depending on the magnetic field are studied, and the asymptotic solution to the initial boundary value problem is proposed. How the application of time-dependent magnetic fields yields a soft suppression of the running waves is demonstrated.

Chapter “[The Vehicle Tire Model Based on Energy Flow](#)” is focused on modelling a tire–ground interaction dynamics based on free energy flow between three layers including a flexible tire, a tire–ground system with friction and the ground. Simulation results obtained with the employment of MATLAB/Simulink are compared with real test data.

Młyńczak et al. (Chap. “[Research on Dynamics of Shunting Locomotive During Movement on Marshalling Yard by Using Prototype of Remote Control Unit](#)”) have presented a remote monitoring system using mobile devices for monitoring of the train driver and the locomotive motion dynamics during manoeuvres. The authors have applied an accelerometer and GPS systems to measure linear accelerations and velocities of the locomotive.

In Chap. “[Durability Tests Acceleration Performed on Machine Components Using Electromagnetic Shakers](#)” the possibility of shortening the durability tests using shakers and standard-defined load power spectral density is illustrated and discussed. The investigations are carried out through modification of the kurtosis, skewness and standard deviations of the applied loading.

Chapter “[Identification of Impulse Force at Electrodes’ Cleaning Process in Electrostatic Precipitators \(ESP\)](#)” presents a proposal of an identification procedure of impulse force at electrodes cleaning process in electrostatic precipitators by means of measurements of vibrations and computer simulations. The analysis consisted of a repeated series of acceleration measurements at several tens of points of the collecting electrodes.

A new model of energy harvester based on a simple portal frame structure under saturation phenomenon is presented in Chap. “[Using Saturation Phenomenon to Improve Energy Harvesting in a Portal Frame Platform with Passive Control by a Pendulum](#)”. Optimization of power harvesting and stabilization of chaotic motion to a given periodic orbit are achieved using the average power output and bifurcation diagrams. In addition, control sensitivity to parametric errors in damping and stiffness of the portal frame is implemented.

Štefek et al. (Chap. “[Differential Drive Robot: Spline-Based Design of Circular Path](#)”) have discussed basic principles of control of a robot with differential drive and its application to design a circular path. The obtained results are verified in a simulator.

In Chap. “[Multiple Solutions and Corresponding Power Output of Nonlinear Piezoelectric Energy Harvester](#)” dynamics of a nonlinear flexible beam with a piezoelectric layer and magnetic tip mass subjected to harmonic excitation is studied. The introduced magnets define the system multistability, including a tristable configuration. It is shown that the constructed resonant curves and basins of attractors can help in choosing the optimal system parameters.

Chapter “[On the Dynamics of the Rigid Body Lying on the Vibrating Table with the Use of Special Approximations of the Resulting Friction Forces](#)” reports simulations and dynamics investigation of a rigid body lying on a vibrating table. The authors have employed a special approximation of the integral friction models based on the Padé approximants and their generalizations to attempt shaping and control of the body dynamics.

A system of two material points that interact by elastic forces due to the Hooke's law accompanied by their motion restricted to certain curves lying on a plane is studied in Chap. "[Analysis of a Constrained Two-Body Problem](#)". Conditions of linear stability are defined and a few particular periodic solutions are identified.

Warczek et al. have analysed forces generated in a shock absorber at conditions similar to the excitation caused by road roughness in Chap. "[Analysis of the Forces Generated in the Shock Absorber for Conditions Similar to the Excitation Caused by Road Roughness](#)". Defined random signals are supplied as the input functions which correspond to the real spectral density of road inequalities.

Chapter "[A Pendulum Driven by a Crank-Shaft-Slider Mechanism and a DC Motor—Mathematical Modeling, Parameter Identification, and Experimental Validation of Bifurcational Dynamics](#)" reports a continuation of numerical and experimental investigations of a system consisting of a single pendulum with the joint horizontally driven using a chainset (crankset) and a DC motor. The carried out series of experiments has given accurate estimation of the model parameters.

Bio-inspired tactile sensors for contour detection using a FEM-based approach are proposed in Chap. "[Bio-Inspired Tactile Sensors For Contour Detection Using an Fem Based Approach](#)". The work is focused on mechanoreceptors built as models of mystacial vibrissae located in the snout region of various mammals, such as mice, cats and rats.

Chapter "[Kinematics and Dynamics of the Drum Cutting Units](#)" is aimed at determination of the relationships between the basic parameters and the construction features of cutting drums. The obtained dependencies can be applied to construct a new prototype of a drum of cutting assemblies.

I hope that this book will provide the readers with both the response to their problems and the inspiration for further research.

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