Preface

It is well known that dynamic phenomena dominate in nature and real-world applications, and that static behaviour can be treated as a particular case of dynamics. Analysis of dynamics can be performed in theoretical, numerical and analytical ways or through experimental observations. This universality of the term of dynamical systems becomes the driving force to make it possible for scientists and researchers from different fields to meet in one place and share results of their investigations. In this book, we provide a part of the results presented during the 13th edition of the conference series devoted to dynamical systems that took place in Lodz (Poland) in December 2015. The comprised research allows to exchange ideas from different branches of theoretical and applied sciences, including not only applied mathematics, physics and mechanics, but also mechatronics, electrical engineering, biomechanics and others.

In Chap. "On Dynamic Behavior of a Nonideal Torsional Machine Suspension Structure", a mathematical model of a nonideal torsional machine suspension structure has been proposed. Natural frequencies of vibrations and the associated modes have been computed. In addition, regions of stability, instability and chaos have been reported.

Babich et al. (Chap. "Structural Probabilistic Modeling of Fatigue Fracture for Piezoceramic Materials Under Cyclic Loading") have developed a structural approach aimed at construction of a statistical criterion of static and fatigue failure for transversely isotropic piezoelectric materials. Daniel's structural model of micro-cracks accumulation as well as the statical criterion has been employed to study fatigue failure under cyclic loading. The research includes derivation of constitutive equations for a damaged material, the fracture criterion and the distribution of micro-damage load. The applied approach has allowed to estimate the residual ultimate strength of the material and the conditional fatigue limit.

In Chap. "Numerical Analysis of Child Restraint System Equipped with Built-in Belts Pretensioner During Frontal Impact", a practical modelling methodology has been proposed regarding the child restraint system equipped with built-in belts

pretensioner during a frontal impact. The effectiveness of the proposed solution has been validated through numerical and experimental tests.

Barros et al. have studied dynamic behaviour of a metallic steel tower supporting a radar antenna, taking into account wind and seismic action (Chap. "Analysis of the Dynamic Behavior of a Radar Tower"). The control of tower vibrations by design and installation of tuned liquid dampers near the top of the radar tower has been also proposed.

Chapter "Determination of the Fatigue Life on the Basis of Fatigue Test and FEM for EN-MCMgY4RE3Zr with Rare Earth Elements" deals with both experimental and numerical investigations of the fatigue wear of an alloy with rare earth elements. Effects of appearance of fatigue cracks based on the alloy composition, morphology and structure have been studied both numerically and experimentally.

Biesiacki et al. have studied dynamic forces in a human upper limb in a forward fall (Chap. "Modelling of Forward Fall on Outstretched Hands as a System with Ground Contact"), putting emphasis on the usually neglected inertia forces. A simplified mechanical model of the human body biokinematic chain has been constructed and then numerically validated.

Chapter "Micelle Confined in Aqueous Environment: Lubrication at the Nanoscale and Its Nonlinear Characteristics" presents simulation results of the constant pressure molecular dynamics of a micelle confined between the surfaces in an aqueous environment. The carried-out analysis yielded an insight into lubrication at the nanoscale of an articulating system.

Chapter "The Sensitivity Analysis of the Method for Identification of Bearing Dynamic Coefficients" is aimed at the sensitivity analysis of the method for identification of bearing dynamic coefficients. The excitation signals and the corresponding system responses have been employed to determine the mass, damping and stiffness coefficients using the impulse excitation technique.

In Chap. "Investigations of Composite Panels Mounted in the Cargo Space of a Freight Wagon", investigations on composite panels mounted in the cargo space of a freight wagon have been carried out. The stress/displacement has been measured in the characteristic points of the side wall of a wagon using the displacement tensors and templates for gap measuring.

Principles of construction of a laboratory stand for vibration testing of a freight wagon have been given in Chap. "Project of Laboratory Stand, and Preliminary Studies of Vibration Shell Freight Wagon". The employed measuring system consists of a drive unit with a freight wagon, a control unit with an inverter and the programmable PLC. In particular, the control panel has been applied to perform long-term studies by means of termination of the number of crossing between gates.

Chapter "Analysis of Dynamical Response of the Freight Wagon" presents the CAD model of a freight wagon as well as its model analysis before and after implementation of new composite materials. Measurements of vibrations have been conducted using piezoelectric foils. The carried-out research is aimed at modernisation of freight wagons during their periodic repairs.

A numerical procedure for the generalisation of sets of synthetic acceleration time histories compatible with an assigned target spectrum has been implemented by Carli and Corina (Chap. "Evolutionary Model for Synthetic Spectrum Compatible Accelerograms"). Both energy distribution in time and contemporary variability of the frequency content have been taken into account.

Christov et al. have performed a parametric study of mixing in a granular flow a bi-axial spherical tumbler in Chap. "A Parametric Study of Mixing in a Granular Flow a Biaxial Spherical Tumbler". The symmetric case has been considered in which the flowing layer depth is the same for each rotation. It has been shown that most choices of angles and most shells (concentric spheroids) throughout the tumbler volume mix well, although there also exist examples of pathological mixing.

Numerical simulation of abrasive wear using the FEM-SPH hybrid approach has been carried out in Chap. "Numerical Simulation of Abrasive Wear Using FEM—SPH Hybrid Approach". The analysis is aimed at the dynamic interaction of counter surface with lining samples rotating with an angular speed. The global model is studied using the finite elements method (FEM), whereas abrasive wear is modelled via the smooth particle hydrodynamics (SPH). In addition, thermal–mechanical coupling and heat generation by friction forces are also included in the modelling process and analysis.

Chapter "A Mathematical Model for Robot-Indenter" presents a study of a dual-arm robot manipulator for executing medical procedures. The investigations take into account torques produced by manipulator motors as well as friction and contact interactions. The applied control aims at obtaining the required indentation of the sensor head into a soft tissue under a few introduced restrictions.

Chapter "A Docking Maneuver Scenario of a Servicing Satellite—Quaternion-Based Dynamics and Control Design" presents a quaternion-based dynamics and control design for a servicing satellite approaching a client satellite. The presented model consists of reaction wheels, thrusters, a drift caused by solar radiation and atmosphere. The novelty of the research is illustrated by a simulation example regarding orbit navigation, attitude control and direct satellite approaching.

The experimental study of the nonlinear dynamics of a vibration harvest-absorber system is presented in Chap. "Nonlinear Dynamics of a Vibration Harvest-Absorber System. Experimental Study". In particular, an induced (with added harvester device) main resonance region has been detected. The influence of the excitation frequency and resistance load on the system dynamics is investigated as well as the mathematical model of the magnetic levitating force has been proposed.

In Chap. "Three-Chamber Model of Human Vascular System for Explanation the Quasi-Regular and Chaotic Dynamics of the Blood Pressure and Flow Oscillations", the arterial blood pressure and flow curves exhibiting quasi-regular and chaotic dynamics have been analysed. It has been found that the quasi-regular dynamics, consisting of different patient-specific patterns of the attractor, correspond to variations of the material parameters within the physiological limits. On

the other hand, it has been detected that the chaotic dynamics appears when wall compliance and/or resistivity of the chamber is too high.

The control study for a vibratory robot modelled by a rigid box with a pendulum enclosed inside has been proposed in Chap. "Maximization of Average Velocity of Vibratory Robot (with One Restriction on Acceleration)". It is assumed that the robot moves forward and backward, and the Coulomb friction is taken into account. It has been demonstrated how the proposed control not only provides motion within the constraints and limitations, but also maximises average robot velocity.

Asymptotic solution to the problems of convective diffusion around the cylinder streamline cross-flow of fluid at low Reynolds numbers has been proposed in Chap. "Asymptotic Solution of the Problem to a Convective Diffusion Equation with a Chemical Reaction Around a Cylinder". The leading terms of the asymptotic solution around the cylinder are constructed employing the method of matched asymptotic expansions.

In Chap. "Assessment of Eigenfrequencies of the Middle Ear Oscillating System: Effect of the Cartilage Transplant", the finite element models of the intact middle ear and a diseased one with eardrums subjected to retractions in the posterosuperior quadrant have been presented. The geometric model of the middle ear consisting of the eardrums, malleus, incus and stapes has been yielded by the tomographic data. The optimal thickness of the cartilage transplant is chosen in a way that the natural frequencies of the reconstructed middle ear are close to the natural middle ear frequencies.

Chapter "The Method of Modeling Human Skeletons Multi-Body System" is devoted to the modification of multi-body system aimed at force and moment modelling for a lower limb exoskeleton design. The introduced modelling of a human skeleton consists of stiff branches (bones) accompanied by flexible and rotatable modes (joints).

It is shown in Chap. "Fragility Estimation and Comparison Using IDA and Simplified Macro-Modeling of In-Plane Shear in Old Masonry Walls" how the fragility function estimation combined with dynamic structural analysis yields an estimation of the magnitude of historical seismic events relying on the behaviour and damage in real historical structures. The employed type of identification strategy resulted in incremental dynamic analysis and efficient fragility function.

An analytical model of the dynamic characteristics of the test system has been proposed in Chap. "Analytical Model of Dynamic Behaviour of Fatigue Test Stand—Description and Experimental Validation". The test system modelled by one and two degrees-of-freedom systems has been applied for fatigue life determination of structural materials by using bending moment resulting from inertia forces.

The methods aimed at safety estimation of buildings subjected to dynamic loads have been presented in Chap. "Assessment of Modal Parameters of a Building Structure Model". Results of the finite element modelling of the column-beam-plate systems has been compared with laboratory tests.

A model of bus dynamics as a tool of energy consumption estimation has been proposed in Chap. "Simplified Model of City Bus Dynamics as a Tool of an Energy Consumption Estimation". Measured average fuel consumption, maximum vehicle

speed and time acceleration have been used as the reference parameters and then been employed to tune the simulation model.

Chapter "Modeling of Buildings Behavior Under Blast Load" concerns the modelling of the behaviour of buildings of reinforced concrete structures under a blast load. The material model has been verified using the beam and deep beam under dynamic loadings. Two types of buildings have been investigated: (i) slabs-column type of structure; (ii) walls type of structure. Displacements as well as the stress–strain states have been computed.

Measurement of the force strike of an athlete who perform competitively combat sports has been reported in Chap. "Force Effect of Strike and the Possibility of Causing a Skull Fracture of a Human Head". Then, the results regarding injuries of a human head caused by impacts of various kinds have been given.

In Chap. "Hydraulically Driven Unit Converting Rotational Motion into Linear One" a unit converting linear motion into linear one, consisting of a stepper motor causing fluid flow through a driving and executive actuators, has been designed and tested. The simulation results conclude very high stiffness and precision of the system, regardless of the applied load.

In Chap. "The Recognition of Human by the Dynamic Determinants of the Gait with Use of ANN", a human recognition method based on dynamic parameters of the human gait is presented. In the method development, artificial neural network algorithm has been employed. All gait parameters have been calculated on a basis of examination of fifteen people with different gait characteristics. Three configurations of the input data have been investigated.

Chapter "Optimization of Micro-Jet Selective Cooling After Low Alloy Steel Welding" is aimed at optimisation of micro-jet dynamical systems cooling after steel welding. The employed method yields very good mechanical properties of low-alloy steel with various micro-jet gases. The developed dynamical systems of micro-jest cooling can find numerous applications in the automotive industry.

Modelling of thermoplastic processes in FEM environment based on experimental results has been employed in Chap. "Modelling of Thermoelectric Processes in FEM Environment Based on Experimental Studies". The modelling process consists of geometry design, sensitivity analysis focused on solver settings discretisation level and their impact on the results. The research output yields the Peltier modulus FE models database to be directly applied in the energy production industry.

Chapter "The Modeling of Nonlinear Rotational Vibration in Periodic Medium with Infinite Number of Degrees of Freedom" is focused on modelling of nonlinear rotational vibration in periodic medium with infinite number of degrees of freedom. In the case of the physical atmospheric phenomena, the hypothetical plates are implemented by electrically charged plates of ice crystals. The author has developed a continuous nonlinear vibration model of the considered medium.

In Chap. "Numerical Model of Femur Part", the authors have developed a numerical model of a femur part using the finite element method. The femur part has been treated as a complex structure composed of a tubercular bone (internal part) and a cordial bone (external part). Similar load boundary conditions including

muscles forces and external moments have been applied. The carried-out research resulted in numerous conclusions regarding the influence of a material/geometric properties and units on a direct application of the employed method in clinical biomechanics.

Chapter "FEA-Based Design of Experiment for the Damping Determination of Thermoplastic-Rubber Compounds" aims at a FEA-based design of an experiment for the damping deformation of thermoplastic-rubber compounds. In the case of different testing conditions, the average strain energy has been estimated numerically since it cannot be directly measured. As an example, cyclic tension and free decay of cantilever beams have been experimentally analysed and numerically validated.

The so far presented and briefly described research results included in this book illustrate the importance of the development of dynamical systems in both theoretical and experimental aspects.

Finally, it has to be mentioned that I do greatly appreciate the help of the Scientific Committee members of the *Dynamical Systems-Theory and Applications* conference, who took part in the review procedure of this book. I would like to also thank the Springer Editor, Dr. Elizabeth Leow, for her support and fruitful collaboration in finalising this book as well as to thank all the referees for their time and help with ensuring that this manuscript is as good as possible.

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