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Guest Editorial

Nonlinear vibrations in elastic structures: Dynamics and control

The aim of this special issue was to gather specialists of different areas working on the nonlinear dynamics and vibration control of engineering problems. Due to the actual demands of the modern technology and the increasing slenderness of structural elements, it is unavoidable to take into account nonlinearities of the basic equations in their mathematical modeling. New phenomena in dynamics as well as new approaches to older ones are expected to be discovered in the theoretical, numerical and experimental investigations of these structures. The various current and potential applications of the knowledge about nonlinear systems in engineering sciences are being intensively demonstrated by ongoing research activities worldwide.

The selected contributions of this special issue shed light on a series of interesting problems related to nonlinear dynamics and control with the aim of demonstrating some of their interesting applications in a series of selected practical problems. This special issue contains eight papers.

Warminski et al. studied the application of the nonlinear saturation control algorithm (NSC) to a self-excited strongly nonlinear beam structure driven by an external force. The mathematical model is based on the Euler-Bernoulli beam theory with nonlinear curvature. The dynamics of the beam under a harmonic excitation close to the first natural frequency of the beam and a fluid flow is investigated by the multiple time scales method, up to the first-order approximation. The analytical solutions have been compared with numerical results obtained from direct integration of the ordinary differential equations of motion. Finally, the influence of a negative damping term and the controller's parameters for effective vibrations suppression are presented.

Fenili investigates the angular position and vibration control of a nonlinear rigid-flexible two link robotic manipulator considering fast angular maneuvers. The nonlinear control technique named State-Dependent Riccati Equation (SDRE) is used. It is considered that some states can be measured and some states cannot be measured. The states not measured are estimated in order to be used in the SDRE control. Different initial conditions and mathematical model are considered to verify the limitations of the proposed state estimation and control techniques and the results for the different approaches are compared and discussed.

The nonlinear dynamics of a non-ideal auto parametric system with a double pendulum and a MR damper is investigated by Sado. The system is excited by a DC motor which works with a limited power supply. The influence of damping force of the MR damper on the phenomenon of energy transfer is studied numerically near the internal and external resonance regions. Periodic and chaotic vibrations are observed.

Carvalho et al. studies the nonlinear nonplanar vibrations of a slender cantilever beam subject to a concentrated axial load and a lateral harmonic excitation. Special attention is given to the effect of the axial load on the frequency-amplitude relation, bifurcations and instabilities of the beam. The nonlinear integro-differential equations, including both inertial and geometric nonlinearities, are used to study the flexural-flexural-torsional coupling of the beam. Due to symmetries of the cross section, the beam exhibits a 1:1 internal resonance which has an important role on the nonlinear oscillations and bifurcation scenario. A detailed parametric analysis using several tools of nonlinear dynamics unveils the complex dynamic behavior of the beam in the parametric and external resonance regions. Bifurcations leading to multiple coexisting solutions are observed.

De Paula et al. study the nonlinear dynamic interactions between a flexible portal frame and a nonlinear support excitation provided by an electro-dynamical shaker. The dynamic analysis is carried out numerically considering different forcing frequencies in the main resonance region. The occurrence of jump phenomenon associated with coexisting periodic attractors and its influence on the shaker and portal frame is investigated.

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Freundlich analyzes the nonlinear vibrations of a simply supported beam excited by the supports movement with a fractional order viscoelastic material model. The Bernoulli-Euler beam model is considered. The Riemann–Liouville fractional derivative of order $0 < \alpha \leqslant 1$ is applied to obtain the amplitude-frequency characteristics of the examined system. The influence of the fractional order derivative and values of the Voigt material model parameters is investigated, enabling the derivation of accurate mathematical models.

Finally, Welte et al. investigates the influence of parametric excitation on the dynamic stability of a microelectromechanical system. The influence of the number of degrees of freedom on the unstable behavior within certain intervals of the parametric excitation frequency is analyzed. Both the parametric resonance and anti-resonance are modeled and studied for a microelectromechanical system with two degrees of freedom and some novel results are discussed.

The topics of these contribution were selected from the works presented in the symposium on Nonlinear Dynamics, Chaos and Control of Macro Elastic Structures, Including MEMS and NEMS and Applications, as part of the ICNPAA 2012 World Congress, held at the Vienna University of Technology, Austria, July 10–July 14, 2012.

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