# Special issue on Control of nonlinear systems

# Preface

Nonlinear systems present mathematical challenges that, even if studied intensively during the last four decades, still offer wide room for specific research efforts. In this special issue, the topic of discussion is the manner in which the response of such systems can be controlled. Including the nonlinearities in the design of the controllers is often a difficult task, so that relevant research efforts are dedicated to the development of simplified modelling techniques able to ensure a correct performance of the controllers.

When finite element models of large civil structures with nonlinear behaviour are considered, the adoption of model order reduction techniques (Casciati and Faravelli 2016) which preserve the dynamical features of the underlying high dimensional, second-order system is of great interest in view of structural control applications. Slender footbridges with either a cable-stayed (Casciati 2016) or suspended (Preumont *et al.* 2016) structural scheme and a span greater than 100 m represent a convenient test-bed for active control solutions due to their high sensitivity to dynamic actions. In particular, the variation of the tension in the stays under human induced loading and its effects on the deck's modal features result in a time varying space matrix which calls for piecewise linear or fully nonlinear active control algorithms . Alternatively, simple prediction formulae based on linear models may be used for the design of decentralized active tendon control of cable-structures, but they must be supported by experiments. Off-line control solutions should also be conveniently investigated where possible.

The semi-active control option offered by MR (magneto-rheological fluid) dampers paves the way to innovative solutions for vibrations mitigation. MR dampers with different control ranges are designed and tested by real-scale experiments to realize tunable secondary suspensions for lateral vibration suppression in high-speed trains (Ni *et al*. 2016). A specific semi-active logic (Caterino *et al.* 2016) is designed and calibrated to protect wind turbine towers during strong storms by a time variant restraint realized with MR dampers at the base of the tower

Wide frequency band vibrations reduction in wind-excited high rise buildings can be effectively pursued in a passive manner by the use of particle tuned mass dampers (Lu *et al*. 2016) which permit to dissipate the input energy through tuned mass plus the friction and the impact between particles and the wall of the containers. The high non-linearity of this phenomenon, and the presence of noise and impact force, call for the development of practical design methods based on experiments and numerical methods.

A formulation of the TLCD (tuned liquid columns damper) controlled systems using fractional derivatives is shown to allow a good agreement with the experimental results; furthermore, since the proposed model is linear, the system parameter identification is extremely simpler than the classical nonlinear one (Di Matteo *et al.* 2016).

The task of shape morphing (Irschik *at al*. 2016) of a pre-deformed structure can be accomplished by a smart actuation such that the incremental displacements coincide with some desired time-dependent small (infinitesimal) displacement field with corresponding small deformations. The incremental actuation stress is taken as a linear mapping of actuating non-mechanical fields, such as the electric field or temperature in a thermo-piezo-elastic body. An exact solution to this problem is presented and demonstrated via finite element computations for an irregularly shaped four-corner plate in a state of plain strain.

The nonlinear behaviour of thin plates with embodied piezoelectric transducers (Krommer *et al*. 2016) is studied, and the stability of the equilibrium and the post-buckling behaviour are discussed.

The suitability of perturbation methods (Luongo *et al*. 2016) to derive approximate expressions for the periodic solutions of nonlinear systems is demonstrated with reference to a bi-stable oscillator under slow harmonic excitation.

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