MODEL ORDER REDUCTION STRATEGIES FOR NONLINEAR MICRO-ELECTRO-MECHANICAL SYSTEMS

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Abstract

A few years ago, the spread of Micro-Electro-Mechanical Systems (MEMS) in the consumer world triggered a revolution of user interfaces in gaming, mobile phones and navigation. Similarly, in the near future, new generations of sensors and actuators will enable the evolution of Internet of Things in its different declinations such as Smart City, Home, Farming, Objects and Driving.
These innovative MEMS come with a cost, i.e. an increase of the device complexity. Outstanding performances demand a novel systematic approach for the design of nonlinear multiphysics MEMS.
The description of the dynamical behavior of MEMS devices like gyroscopes, micromirrors, loudspeakers and energy harvesters generates time-dependent, nonlinear, multi-physics models including electromagnetics, piezoelectricity, fluid-structure interaction. Problems are set on intricate geometrical configurations and are burdened by uncertainties on material parameters and fabrication imperfections. This makes traditional full-order simulation strategies extremely expensive, if not infeasible.

We will describe a new generation of efficient and reliable model order reduction techniques able to span over multiple physics and to capture intrinsic nonlinearities, to effectively support the design and the experimental validation of nonlinear MEMS. This objective is pursued extending classical formulations such as the Implicit Condensation approach, the method of Nonlinear Normal Modes and the Proper Orthogonal Decomposition conjugated in its variants tailored for nonlinearities. Finally we will discuss how these tools can be enhanced with deep learning approaches generating a new class of deep learning Reduced Order Models and Physics-Informed Neural Networks that characterize MEMS in a nonintrusive way.

Presentation time

10.15 - 10.30