Computational Issues in the Nonlinear Dynamics and Control of Macro/Micro-Mechanics

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Abstract

Most of the advancements occurred in the last two decades in the nonlinear dynamics of systems/structures undergoing finite amplitude vibrations have involved a variety of computational issues concerned with both the detection of local and global bifurcations governing the overall response scenario and the reliable characterization of its complex dynamics. This lecture deals with the fundamental role played by global dynamics for a comprehensive description and understanding of the response scenario, with also important impacts on the evaluation of the actual system safety.

Under variation of a control parameter (e.g. the excitation amplitude), topological features of basins of attraction are meaningfully modified, with possibly fractal behaviors entailing mutual erosion of competing basins and final settling of the whole dynamics onto a possibly undesired 'escape' solution, whose physical meaning depends on the system under consideration. Safety with respect to escape has to be evaluated in terms of non-residual dynamical integrity [1], i.e. of the extent/compactness of the basin of a wanted response such to guarantee its adequate robustness with respect to the non-infinitesimal variations of initial conditions representative of the unavoidable disturbances/imperfections occurring in real situations. The steps to be pursued within this overall framework entail challenging computational aspects, which meaningfully depend on also the system dimensionality.

(i) Selecting and comparatively calculating integrity measures reliably accounting for the evolution of fractal features of basins of attraction with the varying control parameter [1].

(ii) Identifying the saddle, among the many exhibited by the system in its complex evolution, whose invariant manifolds tangency triggers the fractal dynamics later on entailing the sharp erosion of the integrity profile which ends up to escape [2].

(iii) Implementing/optimizing a control procedure of the homo/heteroclinic intersection of the saddle(s) stable and unstable manifolds able to shift the sharp basin erosion towards higher values of the control parameter, preserving an acceptable residual integrity [1, 2].

(iv) Pursuing global analyses and integrity evaluations via properly selected 2D cross-sections of basins of attraction [3] or more reliable calculations in the actual multidimensional phase space [4], made possible by the implementation of parallel computing techniques.

References

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