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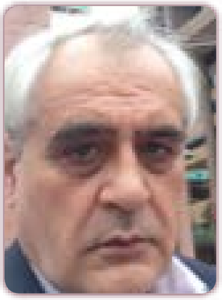

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Advanced Proper Orthogonal Decomposition (POD) tools for geometric modal analysis of big dynamics-datasets of complex structural systems in engineering

The typical aerospace and ocean platform is a quite complicated structural system interacting with the environment and the installed propulsion and energy conversion machinery. The full order dynamics response of such a complex system is coupled and nonlinear and in local critical areas exhibits multi-physics interactions (solid-fluid, solid-thermal, solid-thermal-electromagnetic). The full order multi-physics interaction renders the interpretation of a sensory information quite difficult for early-stage damage diagnostics. The realistic full order dynamics could be in contrast to the reduced order dynamics used in a classical model-based analysis. Full order dynamics should be subjected to a reduction process for obvious reasons. Given the fact that modern information technology has revolutionized the design-monitoring of the aerospace and ocean platform, rapid generation of datasets for the full order dynamics can occur on a routine basis via the following mechanical engineering practices: (1) the use of high fidelity computational models in design and (2) the use of a dense network of high performance sensors (accelerometers, fiber optics, strain gauges). The pivotal observation is that the connection between the coupled dynamics and the spatial features of the complex structure is carried implicitly in the raw datasets. These space-time datasets contain the essential features of the dynamics of the complex structure and definitely should form the basis for a pure data-driven analysis in analogy to the classical model-driven analysis. The pivotal point to start is to view the dataset as a geometric object embedded in the hyperspace of observations. The cloud formed by the space-time dataset processes necessarily stationary geometric features. This intrinsic properties-referred to as POD modes-of the cloud can be identified exactly by the powerful proper orthogonal decomposition or projection data processing procedure. We have advanced the proper orthogonal decomposition for scalar fields to compute the POD modes of nonlinear coupled multi-dimensional fields in structural dynamics by using as the prototype the finite element simulations of the coupled dynamics of nonlinearly elastic rods and shells. These advanced POD tools were used to explore the full order dynamics of quite complicated structures (sandwich structures, ship frames, flexible machinery mechanics) (Project-PYTHAGORAS). The advanced POD tools were used to investigate the experimental dynamics-for advanced diagnostics-of a range of technology important physical complex structures with local critical areas (Project-IMS-PB-DIAGNOSIS). The systematic research establishes the fact that advanced proper orthogonal decomposition tools offer an unparalleled procedure to exploit in depth big datasets produced during the design and subsequent vibrations-based structural-machinery monitoring of aerospace and ocean systems. The POD-based geometric modal analysis is data-driven and independent of the geometric features of the structural system. Given the powerful geometric modal-like properties of the POD Transform, big datasets of the full order dynamics of complex structural systems are reduced into multiscale orthogonal resolutions. The classical modal analysis cannot operate on the dataset level as the POD does. An advanced POD is the ideal multiscale decomposition tool.

Biography

Ioannis T Georgiou completed his PhD in Aeronautical and Astronautical Engineering in 1993 at Purdue University and contacted postdoctoral studies in Nonlinear Dynamics-Chaos of Structural-Material Systems at the USA Naval Research Laboratory (NRL). He has performed research for 20 years on the modeling and data-driven analysis of complex structures by developing multiscale analysis tools based on proper orthogonal decompositions and geometric slow-fast time decompositions. His current research focuses on advanced diagnostics of complex mechanical and biomechanical structures. He has published around 200 papers in reputed journals and conference proceedings and serving on the editorial board of big data and cloud innovation journal. He is the director of the Laboratory of Dynamics-Acoustics & Diagnostics at National Technical University of Athens

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