REDUCED-ORDER MODELING OF STRONGLY NONLINEAR MODAL INTERACTIONS THROUGH SLOW-FAST PARTITION OF THE DYNAMICS AND EMPIRICAL MODE DECOMPOSITION

Alexander F. Vakakis
Mechanics Division
National Technical University of Athens
vakakis@central.ntua.gr

Abstract

We perform nonlinear system identification of strongly nonlinear transient modal interactions occurring in essentially nonlinear dynamical systems. The nonparametric identification is performed by, (i) slow – fast partition of the transient dynamics through a complexification – averaging technique, and (ii) Empirical Mode Decomposition (EMD) of the nonlinear time series of the responses, applied together with the numerical Wavelet Transform (WT). We show that the dominant intrinsic mode functions (IMFs) resulting from EMD coincide with the slow-flow responses, so they have physical meaning. Based on this observation, we formulate a reduced-order modeling methodology that can find applicability to a broad range of applications involving nonlinear modal interactions. We demonstrate application of this methodology by considering the problem of aeroelastic instabilities of in-flow rigid wings, and the problem of resonance interaction of an elastic medium with an essentially nonlinear attachment to its boundary. The proposed methodology can be used for multi-scale identification of complex nonlinear dynamical phenomena, and for the derivation of physics-based reduced-order models that capture the important dynamics of the processes under investigation.