Identification of the Slow-Flow Dynamics of Transonic Aeroelastic Response from Time-Series Data

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Recent advances in the nonparametric identification of strongly nonlinear dynamic systems hold promise for generating low-order models capable of reproducing complex responses, including transient internal resonances, frequency shifts, and energy transfer between substructures [1, 2]. The techniques employed here build on the empirical mode decomposition and exploit the established relationship between the intrinsic mode functions extracted by the EMD and the slow-flow dynamics of the unknown system. In this paper, this slow-flow system identification (SFID) technique is applied to time-series data generated through the high-fidelity numerical simulation of the response of a flexible airfoil in transonic slow. Specifically, modal displacements and slopes obtained from linear finite element analysis of a jet-transport wing have been used along with the transonic small disturbance equations, as solved in discretized form by NASA's CAPTSDv program, to compute realistic aeroelastic responses under various flow conditions. SFID analysis of the resulting time histories has produced models exhibiting good quantitative agreement with the full simulation, capable of reproducing phenomena such as the transient heave response during the onset of pitch-dominated limit cycle oscillation. The results of this use of SFID are reviewed and their use in structural design alterations are investigated.

References:

[1] G. Kerschen, A. F. Vakakis, Y. S. Lee, D. M. McFarland and L. A. Bergman, Toward a Fundamental Understanding of the Hilbert-Huang Transform in Nonlinear Structural Dynamics, *Journal of Vibration and Control* , **14**(1 2):77 105, 2008

[2] Y. S. Lee, A. F. Vakakis, D. M. McFarland, G. Kerschen and L. A. Bergman, Empirical Mode Decomposition in the Reduced-Order Modeling of Aeroelastic Systems, 49th AIAA Structures, Structural Dynamics and Materials Conference, Schaumburg, Illinois, 7 10April 2008. Proceedings, Paper No. AIAA 2008 2325.