Aerospace Engineering Doctoral Defense

New Applications of Reduced Order Modeling for Geometrically Nonlinear Structures: Highly Asymmetry Structures and Contact Nonlinearity

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Abstract

Over the past few decades there has been significant interest in the design and construction of hypersonic vehicles. Such vehicles exhibit intensely coupled aero-acoustic thermal and structural loadings, which can take significant amounts of computing power to simulation. As a result, tools which simulate these loading conditions cheaper but with similar fidelity to full order simulation are very desirable. In particular this has led to development of various nonlinear reduced order model (NLROM) construction schemes which reduce the parameter space of these simulations so they can be run more quickly. In particular, hypersonic vehicles will certainly be constructed by assembling a series of sub-structures, such as panel and stiffener combinations, that will be welded together. This sort of assembly can then introduce gaps between sub-structures which under these intense loadings can result in contact as well as the opening of interfaces. Built up structures have not previously been investigated in detail in the context of structural NLROMs. Additionally, the nonlinearity introduced by contact separation has never been looked at in the context of structural NLROMs. Modern NLROM construction methodologies were thoroughly investigating in building a NLROM for a hat stiffened panel as an example of a representative built up structure that may be seen in hypersonic vehicle design. A compact NRLOM was successfully built for this structure, which gave insights into complicated behavior that can occur during NLROM construction such as internal resonances. For the investigation of contact separation, and alternative overlapping plate model was used. A NLROM was constructed for the no gap version of this model, and then enriched to take into account the potential for a gap. Adaptions were then successfully made to a Newton-Raphson solve to properly account for contact and the associated forces in static predictions by NLROMs.

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