Reduced-Order Models for Systems with Snap-Through

Max de Bono, Simon A. Neild, Rainer Groh, Thomas L. Hill
School of Civil, Aerospace and Mechanical Engineering, University of Bristol, Bristol, BS8 1TR, UK

Abstract. Traditionally, Reduced-Order Models (ROMs) have been unable to capture the highly nonlinear dynamics of snap-through systems. In the case of morphing aeroelastic structures, the computational cost of optimising multi-stable systems is a major bottleneck in the design process, and accurate ROMs would be a significant step in overcoming this. This work investigates the application of a technique to generate ROMs that can capture large in-plane displacements and demonstrates its applicability to snap-through.

Introduction

Snap-through is an important failure mode in many thin-walled or easily buckled structures [1] and is also used as a mechanism for effectively introducing multi-stability into morphing structures, including next-generation turbine blades and aerofoils [2]. Accounting for snap-through in design requires accurately capturing its dynamics. This is typically highly computationally expensive due to the strong nonlinearity of the phenomenon. Snap-through systems can experience significant in-plane displacements which, traditionally, have been challenging to capture in indirect ROMs. However, with the development of the *Implicit Condensation and Expansion with Inertial Compensation* (ICE-IC) method, the effect of in-plane kinetic energy can be efficiently captured without expanding the reduction basis of the ROM [3]. This work investigates the applicability of this method to snap-through systems.

Results and Discussions

The ICE-IC method is used to compute ROMs for a two DoF, single mass oscillator with significant in-plane kinetic energy and a FE modelled, pinned-pinned, pre-compressed beam. The ROM accurately predicts the backbone curve for the 2 DoF system, which is a marked improvement compared to when the coupled kinetic energy is neglected (see Panel (a) of Figure 1). The dynamics of the FE beam is also well predicted for simple single-mode snap-through, as shown in Panel (b) of Figure 1. However, for increased generality, the reduction basis needs to include at least two unstable modes which results in a far more complex static data set. Further work is required to demonstrate that the dynamics would be well captured by such a ROM.

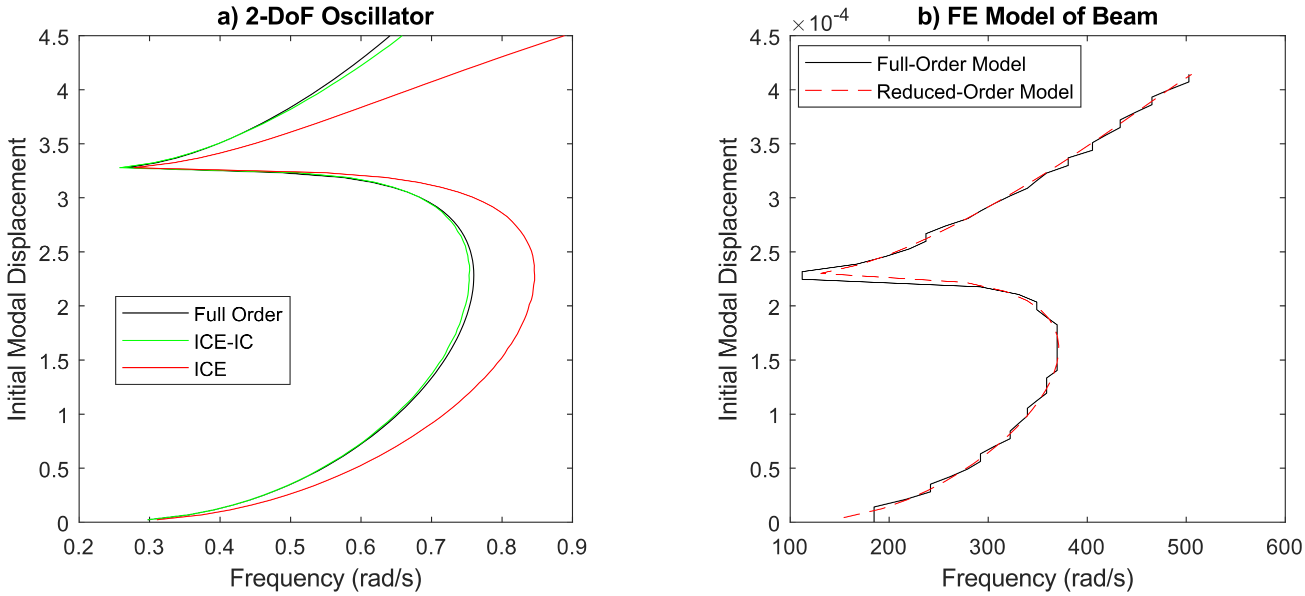

Figure 1: Frequency of the free response for a given initial modal displacement for (a) the 2 DoF system and (b) the FE beam. The full model and ICE-IC ROM are shown in both and the ICE only ROM is given as a point of comparison in the 2 DoF system.

References

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