Parametric Model Order Reduction for Localized Nonlinear Feature Inclusion

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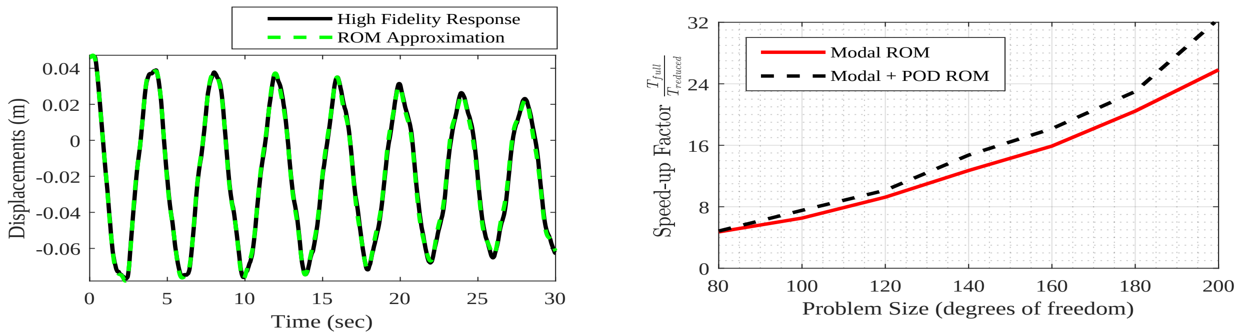
Abstract. Injecting parametric dependency and treating nonlinear phenomena pose main challenges when seeking to construct an accurate Reduced Order Model (ROM) of an actual complex system. In addition, real-life structures may often comprise multiple components demanding separate treatment. A physics-based ROM is derived in this paper, able to reflect dependencies on system properties and characteristics of the induced excitation. This is achieved utilizing projection-based strategies relying on Proper Orthogonal Decomposition. Each component is reduced independently, thus allowing for a modular formulation and adaptive modeling of nonlinear dynamic behavior.

Introduction

The increasing engineering demands require treatment of intricate dynamical systems. By breaking down the system and addressing each component separately, the respective complexity can be reduced. Within a nonlinear context however, additional treatment is required. In tackling this, in [6] modal derivatives are combined with Rubin's method to address geometrical nonlinearities, whereas in [3] a polynomial based approximation is employed for the treatment of nonlinearity within a substructuring context. When aiming to build a digital twin, substructuring may simplify the process of deriving accurate Reduced Order Models (ROMs) by allowing individual reduction of components. In [2] this is achieved via adoption of a nonlinear normal modes strategy coupled with modal synthesis. This paper implements an alternative approach, aiming to remove any dependency on the derivation of nonlinear normal modes. A physics-based ROM is derived by means of a Proper Orthogonal Decomposition (POD), based on the approach in [5]. The substructuring approach described in [4] is coupled with this framework to allow for treatment of individual components featuring nonlinearity.



(a) Accuracy of the pROM approximation

(b) Efficiency considerations for the pROM framework

Figure 1: Accuracy and efficiency considerations for the derived pROM approximation.

Results and Discussion

The derived pROM models the dynamic behavior of nonlinear parametric systems with dependencies pertaining to the structural configuration and/or the characteristics of the applied excitation. The addressed examples of a 1D rod and a 2D cantilever beam feature hysteretic nonlinearities, serve as a proof of concept case study for reduced order modeling in the case of material nonlinearity.

References

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