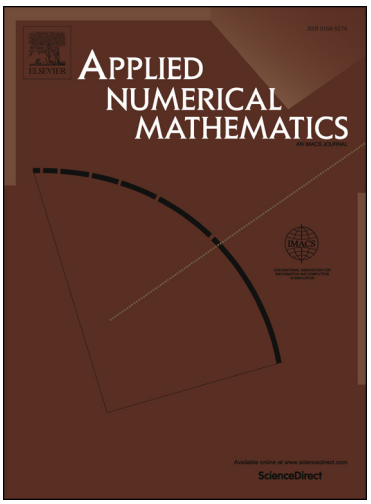

Temporal localized nonlinear model reduction with a priori error estimate

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Temporal localized nonlinear model reduction with a priori error estimate

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Abstract

This work presents a model reduction framework using a temporal localized basis approach to efficiently reduce the simulation time for nonlinear dynamical systems with rapid changes over a short time period, and proposes a corresponding a priori error bound. This framework employs the proper orthogonal decomposition (POD) to construct localized basis sets from different temporal subdomains, which can be used in the Galerkin projection to accurately capture the important local dynamics of the system. The discrete empirical interpolation method (DEIM) with the corresponding temporal localized basis sets is then applied to efficiently compute the projected nonlinear terms. A heuristic procedure for subdividing snapshots over the temporal domain is proposed. This procedure first partitions the set of snapshots where there are possible significant changes in system dynamics, and then uses the notion of distance between subspaces to later remove unnecessary partitioning. An a priori error bound is derived to confirm the convergence of this framework and to explain how the propagated errors from the localized reduced systems affect the overall accuracy. Numerical experiments demonstrate the accuracy improvement of the temporal localized framework through a parametrized nonlinear miscible flow simulation. The results show the applicability of the proposed approach to various parameter values that are not necessary used for generating the POD and DEIM localized basis sets.

Keywords: nonlinear model reduction, proper orthogonal decomposition, empirical interpolation methods, nonlinear partial differential equations, ordinary differential equations
2010 MSC: 65L02, 65M02, 65M15

1. Introduction

Model order reduction (MOR) can be used to decrease the simulation time while maintaining the important features of the original system. It recently has

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