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Kathrin Smetana

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A new certification framework for the port reduced static condensation reduced basis element method

Kathrin Smetana

Department of Mechanical Engineering, Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA-02139, USA

Abstract

In this paper we introduce a new certification framework for the port-reduced static condensation reduced basis element (PR-SCRBE) method, which has been developed for the simulation of large component based applications such as bridges or acoustic waveguides. In an offline computational stage we construct a library of interoperable parametrized reference components; in the subsequent online stage we instantiate and connect the components at the interfaces/ports to form a system of components. To compute a "truth" finite element approximation of the (say) coercive elliptic partial differential equation on the component based system we use a domain decomposition approach. For an efficient simulation we employ two different types of model reduction — a reduced basis (RB) approximation within the interior of the component [Huynh, Knezevic, Patera 2013] and empirical port reduction [Eftang, Patera 2013] on the ports where the components connect. We demonstrate the well-posedness of the PR-SCRBE approximation and introduce a new certification framework. To assess the quality of the port reduction we use conservative fluxes. We adapt the standard estimators from RB methods to the SCRBE setting to derive an a posteriori error estimator for the RB-error contribution. In order to combine the a posteriori estimators for both error contributions and derive a rigorous a posteriori error estimator for PR-SCRBE we adapt techniques from multi-scale methods and component mode synthesis. Finally, we prove that the effectivity of the derived estimator can be bounded. We provide numerical experiments for heat conduction and linear elasticity to show that the derived a posteriori error estimator provides an effective estimator. Moreover we demonstrate the applicability of the introduced certification framework by analyzing the computational (online) costs.

Keywords: A posteriori error estimation, domain decomposition, reduced basis methods
2000 MSC: 65N15, 65N30, 65N55, 65N12

1. Introduction

Within many engineering applications the considered structure allows for a natural decomposition in components. Examples are bridges, buildings, aircrafts, oil and gas platforms, musical instruments or mufflers. One popular method for the simulation and analysis of such large engineering systems is component mode synthesis (CMS). The CMS approach introduced in [1, 2] uses an eigenmodal expansion for the approximation within the interior of the component and static condensation to arrive at a (Schur complement) system associated with the coupling modes on the interfaces or ports. In more recent works also the static or coupling modes are chosen as eigenmodes [3, 4, 5] and used within an adaptive scheme based on a posteriori error

Email address: `ksmetana@mit.edu` (Kathrin Smetana)