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Non-overlapping domain decomposition solution schemes for structural mechanics isogeometric analysis

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Abstract

Isogeometric analysis (IGA) is a novel computer aided engineering technique that addresses diverse problems in computational mechanics [1-4], all under the exact geometric representation. Apart from the exact geometric representation, the high continuity of IGA shape functions enhances the accuracy and robustness of the method. However, the price to pay is that the resulting matrices are denser, with increased bandwidth and overlapping which make the solution of large-scale problems more computationally intensive. As a result, effective solution techniques are still considered an open issue for further research. In this paper, an innovative family of solution schemes based on domain decomposition methods (DDM) is proposed, that significantly reduces the computational cost. Specifically, the solution of the global system is performed with the preconditioned conjugate gradient algorithm (PCG) whose preconditioning step is evaluated with a dual DDM where special care is taken to avoid the overlapped subdomains which are inherent in decomposed IGA formulation due to the increased continuity of the shape functions.

1. Introduction

The relatively new computer-aided engineering methodology called isogeometric analysis (IGA) [5] aims to directly link design and analysis by using the same function spaces. This comes in contrast to the finite element method (FEM) where the description of an object is approximated and a new solution space is created. The intermediate meshing procedure introduces a rough estimation of the real problem and involves a significant computational cost. In addition, the geometry approximation of FEM makes the model error prone, since the accurate geometrical representation is critical in many cases for the accuracy of the solution. But even when the geometry is accurately represented, analysis introduces the need for even more refined meshes to enhance the accuracy of the results. This refinement procedure requires interaction with the design object which is unavailable and thus the analysis model must be redefined all over again.