Extending Domain Decomposition Solution Schemes for Large-Scale Isogeometric Simulations

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ABSTRACT

Isogeometric Analysis (IGA) is an innovative computational methodology proposed in [1] that aims to bridge the gap between Computer Aided Design and Engineering Industries. The major breakthrough of this technology lies on the utilization of the same function spaces for both design and analysis of structures. In contrast to the standard Finite Element technique, meshing procedures are eliminated, thus reducing the analysis cost. However, augmented continuity of the shape functions in IGA results in greater bandwidth and overlapping of the resulting matrices, raising the computational cost of solving the linear system.

Since efficient solution techniques are crucial for the further development of IGA, thorough research is conducted on this topic. An extensive investigation for both direct [2] and iterative solvers [3] has been conducted to establish a relationship between solution cost and number of Degrees of Freedom for varied continuity. The application of domain decomposition methods (DDM) was one of the most efficient proposals, resulting to the development of Isogeometric Tearing and Interconnecting (IETI) [4].

In this work, an efficient, scalable and load balanced solution algorithm is proposed that combines the advantages of the preconditioned conjugate gradient (PCG) algorithm and DDM by introducing an IETI-based preconditioner. The proposed preconditioner circumvents the dependency between domain subdivision and patches that IETI imposes, decoupling load balancing and scalability properties from the model geometry.

The numerical examples contained in this work demonstrate the superiority of the proposed solution algorithm, in both time and iterations when compared to both IETI methodology and popular preconditioners of PCG. As a result, the proposed algorithm enables minimization of the computational cost for solving Isogeometric problems and thus widens the applications of IGA in large-scale real life applications.

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