Mining and Visualizing Recommendation Spaces for Elliptic PDEs on General 2-D Domains

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Abstract

Algorithm recommendation in scientific computing was a problem first analyzed by John Rice nearly 25 years ago. In this paper, we present new results in algorithm recommendation for elliptic PDEs on general parameterized 2-D domains. Such problems find applications in many important application areas, including structural and fluid mechanics. Developers of accurate and efficient solvers for PDEs posed on nonrectangular domains face unique challenges due to the domain itself (the geometry) and due to the PDE operator and solution. For example, domain features such as holes, interfaces, and re-entrant corners usually require special treatment in terms of meshing, discretization, and algorithm and data structure implementation. Similarly, PDE operator or solution features—such as point singularities, boundary layers, and shocks—are often present with highly nonrectangular domains; these also have significant implications for the performance of PDE solvers.

From an algorithm selection point of view, PDE problems on general 2-D domains pose challenges as well. The relative performance of available methods on a variety of problems is not well understood and is difficult to predict. This is the problem we address. In particular, we emphasize (i) the use of domain specific restrictions for the management of recommendation spaces, (ii) mining optimized numeric association rules correlating problem geometry, PDE characteristics and algorithm performance, and (iii) a visualization aid for representing recommendation spaces.

Our experiments are based on a set of problems and domains defined by Rice in 1986. We consider three typical numerical solution algorithms: (i) second order finite differences plus direct linear system solve, (ii) collocation with hermite bicubics plus direct linear system solve, and (iii) piecewise linear, triangular finite elements plus multigrid. Initial results from this approach are encouraging and demonstrate the applicability of database mining technology to a variety of applications in scientific computing.