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Serial and Parallel Implementation of the Interface Relaxation Method GEO [1]

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Abstract

Interface Relaxation (IR) methods are an interesting approach for the solution of multiphysics / multidomain problems. Assuming initial guesses on the interfaces of the original problem, IR methods iteratively solve the subproblems and relax for new values on the interfaces until convergence is succeed. Their main advantages are that their rates of convergence only depend on the parameters of the problem itself, the parameters related to its decomposition into subproblems and the parameters related to the operator imposed on the interfaces. In this paper a new implementation of an IR method named GEO is presented. GEO is based on a simple geometric coorrection mechanism and acts iteratively so as to relax the values of the solution on the interfaces. In particular, it adds to the old interface values a geometrically weighted combination of the normal boundary derivatives of the adjacent subdomains.

In this paper GEO is implemented in FEniCS. The FEniCS project is a collection of free software for automated, efficient solution of differential equations. In order to evaluate the GEO implementation, it is applied on two different PDE problems with the same differential equation and boundary conditions and different domains. FEniCS methods are used to specify the problem's subdomains properties (i.e. geometry, PDE operator and boundary/interface conditions). They are also used to generate and/or refine meshes (triangular elements) for each subdomain, solve the local PDE problems and show the computed results in the global domain and on the interfaces. Getting values of the solutions on the interface (boundaries of the subproblems) and passing the new relaxed values back to the subproblems as updated values for the boundary conditions is the main challenge of the IR methodology implementation and contribution of this paper.

The experiments are performed for 2-dimensional elliptic partial differential model problems with partitions in multiple subdomains and the results are examined in terms of the method's applicability and convergence. The exact solution and the computed approximations on the whole domain and on interface points, are depicted per iteration in appropriate graphs for applicability and convergence evaluation. A parallel implementation of the GEO method using FEniCS is also presented, as well as its performance comparison to the serial implementation.

Key words: Interface relaxation, GEO method, multiphysics problems, parallel implementation, FEniCS.

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