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Recursive Parallel Implementation of Multiscale Mixed Methods

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We are interested in the numerical approximation of partial differential equations of elliptic nature, in the context of incompressible two-phase flow problems in heterogeneous porous media. Numerical solutions of elliptic boundary value problems with high contrast and discontinuous coefficients are often expensive and time consuming, so efficient numerical methods are necessary. Indeed, methods that can take advantage of CPU-GPU clusters are of particular interest because GPUs have larger computational power than CPUs alone. In this work, we focus on the multiscale mixed method MuMM introduced in [1] (see also [2] where the variational formulation of [1] was presented), that is based on a non-overlapping iterative domain decomposition procedure with Robin interface conditions. Local multiscale basis functions are calculated in each subdomain to represent the discrete solutions that can be efficiently computed in CPU-GPU clusters. The method presented here uses a new technique to cluster multiscale basis functions associated with nearest neighbor subdomains, leading to a small (and local) linear system for the interface between the subdomains. The global solution is obtained by recursively applying the MuMM to all pairs of subdomains until the union of subdomains reach the whole domain. The resulting interface linear systems are easily handled by Schur decomposition along with a LU factorization. The novelty of this method is that it does not use an iterative procedure to compute the global solution and shows excellent parallel performance. Numerical experiments related to benchmark problems in petroleum engineering will be presented and discussed.

[1] A. Francisco, V. Ginting, F. Pereira and J. Rigelo, Design and implementation of a multiscale mixed method based on a nonoverlapping domain decomposition procedure, Math. Comput. Simul., 99 (2014) 125-138.

[2] R.T. Guiraldello, R.F. Ausas, F.S. Sousa, F. Pereira and G.C. Buscaglia, The Multiscale Robin Coupled Method for flows in porous media, Journal of Computational Physics, 355 (2018) 1-21.

References

[1] A. Francisco, V. Ginting, F. Pereira and J. Rigelo, Design and implementation of a multiscale mixed method based on a nonoverlapping domain decomposition procedure, Math. Comput. Simul., 99 (2014) 125-138.

[2] R.T. Guiraldello, R.F. Ausas, F.S. Sousa, F. Pereira and G.C. Buscaglia, The Multiscale Robin Coupled Method for flows in porous media, Journal of Computational Physics, 355 (2018) 1-21.

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