PERFORMANCE AND SCALABILITY OF FETI METHODS FOR HETEROGENEOUS DYNAMIC PROBLEMS WITH DIFFERENT COARSE-GRIDS

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ABSTRACT

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Abstract. For the analysis of problems in structural mechanics, the FETI method (Finite Element Tearing and Interconnecting) has established itself as reliable domain decomposition algorithm for large scale problems and parallelization. It is well known that in static problems, difficulties arise when very heterogeneous materials are considered. By heterogeneous material, we mean in general jumps in the coefficients of the governing partial differential equation and in the particular case of static mechanical problems jumps in stiffness. Whether these jumps happen across or along the interfaces that connect substructures or are located completely inside substructures is crucial for the resulting condition number of the operator and thus for the performance of the algorithm. Several methods have been developed and proven to effectively recover convergence rate, robustness and scalability of the algorithm. In most cases, these methods are constructed as preconditioners or coarse-grids, both essential parts of highly performant FETI algorithms. The most recent and effective ones include the coarse spaces constructed from solving generalized eigenvalue problems like proposed by Spillane et al. [1] or Klawonn et al. [2]. When using FETI to simulate the dynamic, time-dependent behavior of mechanical structures, mass appears in the governing equations and jumps in stiffness will coincide with jumps in density in real structures. The FETI operator then results from the application of time-stepping schemes. While a coarse grid is no longer necessary like it is in static problems, it is still essential in dynamics for the algorithm to be scalable. In addition to the coarse-spaces constructed by rigid body modes or eigenvalue problems, more possibilities arise to create such spaces by using the results from former time steps, especially when the same linear problem is solved in every step. In this work, we first analyze for which dynamic problems, regarding the geometry of the structure, heterogeneities and time step, difficulties arise. We apply standard time-stepping schemes like generalized-alpha. Second, we analyze the performance of state-of-the-art preconditioners and coarse space construction methods in terms of convergence rate and robustness as well as numerical scalability and parallel scalability. This will be done using a parallel implementation of the FETI algorithm and we will emphasize computational cost and efficient implementation of the considered methods.

References