Parallel hybrid memory integration for three-dimensional refined isogeometric finite element method computations

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ABSTRACT

The three-dimensional isogeometric analysis is a modern method for simulation of different physical phenomena embedded within the Computer Aided Design (CAD) systems. The idea of isogeometric analysis (IGA-FEM) is to utilize B-splines basis functions or NURBS for both descriptions of the computational domain and the engineering computations. Refined isogeometric analysis (rIGA) [1] employs a mixture of patches of elements with B-spline basis functions, and C^0 separators between them [1]. It enables reduction of the computational cost of direct solvers. Both IGA and rIGA come with challenging sparse matrix structure, that is expensive to generate. In this paper, we show a hybrid parallelization method to reduce the computational cost of the integration phase using hybrid-memory parallel machines. We are aware of the other parallel finite element method packages supporting adaptive computations for IGA, including PETIGA [5] a part of PETSc [2, 3, 4]. The two-level hybrid parallelization includes the partitioning of the computational mesh into several sub-domains on the first level, and loop parallelization on the second level. We employ hybrid MPI plus OpenMP implementation. The hybrid parallelization can be applied for both IGA and rIGA codes. We show that hybrid parallelization of the integration reduces the contribution of this phase below one percent of the total execution time when dealing with parallel direct solvers. Thus, the alternative algorithms for fast isogeometric integration are not necessary when hybrid parallel OpenMP+MPI model is employed.

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