A predictive load balancing approach for parallel anisotropic adaptive finite element solvers in aerodynamics

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ABSTRACT

This work is motivated by the success of the anisotropic adaptive finite element methods in accurately simulating complex physical systems in science and engineering. The parallel implementation of anisotropic adaptive finite element methods is a challenging task for which we should take into account the workload imbalance caused by the dynamic change of the mesh. Indeed, the parallel remeshing involves parallel mesh repartitioning in order to load balance the global workload and reducing interface communications. We have developed and optimized in the last years, tools and algorithms to manage efficiently the dynamic load balancing in the framework of parallel anisotropic mesh adaptation [1, 3].

However, there still complicated and challenging to derive a predictive and quantitative estimation of parallel workload of adaptive finite element meshes. Indeed, the mesh adaptation procedure changes dynamically the size of the mesh over all the processes. This mechanism is managed by an error indicator/estimator that allows to equi-distribute the error over the entire domain by refining and coarsening the mesh in the regions where it is needed [2]. In other words, the size of the problem changes permanently along the runtime execution. The leading questions that arise from this analysis are: how to derive a scalability model to measure the parallel efficiency of a dynamic adaptive simulation? And how to estimate quantitatively the worakload needed to achieve the remeshing stage?

We propose in this paper, an anisotropic a posteriori error estimator that controls the error due to mesh discretization in all space directions. From the a posteriori error analysis, we get an optimal metric (optimal mesh) as a minimum of an error indicator function constrained by a given number of elements. The optimal metric obtained is used to build an optimal mesh for the given number of elements and also to derive a quantitative estimation of the work that will be done in the remeshing stage.

We conduct performance analysis over different aerodynamic turbulent flows to highlight effectiveness of the proposed approach.

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