DEVELOPMENTS OF PARALLEL CURVED MESHING FOR HIGH-ORDER FINITE ELEMENT SIMULATIONS

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ABSTRACT

The high-order finite element methods have the advantage of being able to achieve an exponential rate of convergence in the application to problems of interest that is superior to the linear rate of convergence of conventional finite element methods. However in order to fully realize the benefits of high-order finite elements for large scale simulations over general 3D curved domains, properly curved finite elements must be generated.

The work in this thesis aims to develop reliable and efficient parallel curved meshing techniques to support large scale simulations using higher-order finite element methods. The mathematical fundamentals of the Bézier polynomial based shape representation for high-order curved elements are reviewed. Based on the shape representation, a hybrid shape metric is proposed to serve for both linear straight-sided elements and high-order curved elements. Novel extensions to the Bézier control point based element validity check method are proposed and developed. Numerical experiments have shown results that they are effective with almost neglegible addition to the computational cost.

Technical developments of parallel curved meshing have been presented in terms of creating and adapting partitioned curved meshes. Two alternative approaches to create large partitioned curved meshes have been developed. Efforts have been made to extend linear straight-sided mesh modification procedures to work with high-order curved meshes in parallel. The approach starts from the existing functionalities of parallel linear mesh adaptation and serial mesh curving, both of which have been developed in the SCOREC MeshAdapt software.