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2-D, 3-D and 4-D Anisotropic Mesh Adaptation for the Time-Continuous Space-Time Finite Element Method with Applications to the Incompressible Navier-Stokes Equations

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Abstract

A mesh adaptation strategy suitable for unsteady partial differential equations to control both the spatial and temporal discretization errors in a unified fashion is presented. The aims are to provide a methodology that prevents the accumulation of discretization error associated with time stepping approaches. It is also flexible enough to adjust the density of the space-time mesh to varying time scales in the solution domain.

The primary focus of this work is the development of anisotropic meshing algorithms that can operate in 2-D, 3-D and 4-D on unstructured simplicial meshes. The mesh modification operators include edge splitting, edge collapsing, simulated edge swapping, and mesh smoothing and are driven by an anisotropic metric field.

The mesh adaptation methodology is coupled with a time-continuous space-time finite element flow solver for the incompressible Navier-Stokes equations using an Hessian based error estimator that treats the discretization error in both space and time in a unified fashion. Verifications for the unified space-time adaptive finite element method are done using manufactured solutions for a linear heat equation and for the incompressible Navier-Stokes equations. Classical benchmarks results for incompressible fluid flows are also presented.