GENERAL MESH ADAPTATION USING MESH MODIFICATIONS

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The application of adaptive finite element techniques requires the ability to alter the shape and size of the elements of a given mesh, commonly referred to as h-version mesh adaptation, to match the size and shape distribution as indicated by an error indication procedure. In general, an anisotropic mesh size field specified throughout the domain should be used to represent this desired element size and shape. This paper will discuss a procedure to adapt any given tetrahedral mesh to an anisotropic mesh size field using mesh modifications.

Anisotropic mesh size field is represented by a transformation matrix field that maps an ellipsoid into a unit sphere. The mesh is considered satisfying the mesh size field if all edges of the mesh are unitary in the transformed space. By interacting with an abstract interface wrapping around functionality to interrogate mesh size field, the adaptation procedure is developed independent of any specific mesh size field implementations.

The first step of the procedure incrementally refines and coarsens the mesh based on edge length analysis in transformed space. It begins by computing the range of transformed edge length in the given initial mesh, then repeatedly refines a set of longest mesh edges through a full set of element subdivision templates and coarsens a set of shortest mesh edges using edge collapsing or vertex repositioning operations to narrow the range close to one. To avoid oscillations between refinement and coarsening, the two new mesh edges from splitting an existing mesh edge and any mesh edges created by coarsening are not allowed to be out of the current edge length range.

Since sliver tetrahedra in the transformed space may exist in case all lengths of mesh edges are close to one in transformed space, a second step is necessary to improve mesh quality. The determination of sliver elements is based on one of the standard non-dimensional shape measures in transformed space. By analyzing the sliver element, a few possible local mesh modifications to eliminate it can be efficiently determined, and the one producing best quality will be applied. A algorithm to minimize the volume ratio is followed to further improve the quality of the adapted mesh.

Applications in 3D adaptive flow simulations involving curved analysis domain will be given. Timing and result mesh quality statistics of the adaptation procedure will be provided.