Optimization of Tetrahedral and Hexahedral Mesh Quality

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In this research, a method is presented for improving the quality of tetrahedral and hexahedral meshes. The Reference Jacobian based Mesh Optimization method, as it is called, is designed so that it improves mesh quality while keeping the mesh as close as possible to the original mesh and preserving the characteristics of the boundary surfaces. This technique can be used for the "rezoning" or quality improvement phase of Arbitrary Lagrangian-Eulerian (ALE) simulations where the closeness of the improved mesh to original increases the accuracy of solution transfer. It can also be used in a mesh generator as a post-processing step which improves the quality of the mesh but preserves essential mesh characteristics such as refinement and anisotropy.

The Reference Jacobian based Optimization method consists of two stages. The first stage of the procedure is a local optimization in which the the optimal (*reference*) position of each node is calculated with respect to the fixed positions of its neighbors. The reference positions of nodes are then used to calculate a global objective function whose optimization seeks to find a compromise between the current and the reference positions of the nodes.

In the optimization procedure, interior nodes are repositioned directly by optimizing an objective function with respect to its Cartesian coordinates. However, boundary nodes are repositioned so that they remain on the original surface definition and thereby maintain essential surface characteristics. As described in previous work, the repositioning of boundary nodes is done by moving each node in a local parametric space constructed by a barycentric or isoparametric mapping of the original boundary mesh element it is moving in. Use of such local parametric spaces allows the procedure to be independent of an underlying smooth surface for the surface mesh and avoids the construction of a global parametric space which can be expensive.

The procedure has been tested on a number of tetrahedral and hexahedral meshes and has proved to be very effective in improving mesh quality while minimizing changes to mesh features and boundary surface characteristics.