Mesh Optimization in Sculpt

Mesh Optimization is critical to grid based hex meshing tools such as Sandia’s Sculpt tool. Work was accomplished this year (FY15) to improve overall success of Sculpt by dramatically increasing mesh quality through a new procedure for parallel smoothing. It incorporates Laplacian and Optimization smoothing but adds damping and parallel coloring to achieve improved results.

Sculpt Meshing Procedure

Node Optimization

A combined Laplacian and Optimization smoothing procedure is used. Following a fixed number of Laplacian iterations, Optimization is run until a minimum Scaled Jacobian is achieved.

Parallel Meshing in Sculpt

An overlay Cartesian grid is distributed among processors and a hex mesh is independently generated on each processor for a subset of the Cartesian domain. MPI is used for communication between neighboring processors to ensure continuity across processor boundaries. The same mesh will be generated regardless of the number of processors.

Parallel Smoothing

Ghosted elements and nodes are established and used to facilitate efficient MPI communication following each Jacobian iteration.

Parallel Coloring

The coloring algorithm will attempt to isolate kernels of hexes surrounding a node so that kernels do not overlap. Selection of kernels is ordered based upon minimum scaled Jacobian at the node. For each Jacobian iteration only non-overlapping kernels of hexes are used. For parallel, master nodes must communicate with their ghosted (slave) nodes the minimum scaled Jacobian of their surrounding hexes. This ensures each processor consistently selects the same hex kernels for smoothing.

Smoothing Strategies

For serial applications, where order of operations is normally not important, a Gauss-Seidel approach is used. In order to maintain parallel consistency we use a Jacob-based smoothing procedure.

Damping

With Jacob optimization smoothing it is common to get inverted elements following one or two iterations that are normally resolved with additional iterations. However, there are cases that can oscillate and not allow for improvement. Smooth damping is employed to view convergence avoiding inversions.

Sculpt Smoothing Comparison

Sculpt’s nightly test suite includes a set of 52 single part CAD models. These were used in a comparison study of before and after new smoothing methods were employed.