**Mesh Scaling**

*Generation of Incrementally Finer Meshes for Solution Verification*

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**What is Mesh Scaling?**

Mesh Scaling is a new mesh modification algorithm which, given an input all-hex mesh and a desired element count multiplier, \( N \), will generate a new hex mesh with approximately \( N \) times more/less hex elements, while honoring element size grading and element orientations. Mesh Scaling offers an alternative to traditional uniform mesh refinement (UMR), without the \( 8 \times \) multiplier limitation.

We also introduce the next generation, “Hybrid” Mesh Scaling, which eliminates the paver from the remesh process, enabling algorithmic scaling to HPC platforms.

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**How Does Mesh Scaling Work?**

1. **Step 1: Extract the Block Decomposition:**
   - Hex mesh topology is traversed looking for:
     1. Swept mesh connectivity, AND
     2. Structured zones separated by mesh singularities
   - The mesh is then decomposed into both structured and swept blocks

2. **Step 2: Delete Initial Mesh:**
   - Mesh sizing, grading, orientation, and BC loading are extracted from the mesh and stored in the block decomposition. The original mesh is then deleted.

3. **Step 3: Remesh at any size:**
   - An optimization is performed to compute mesh intervals on all of the curves in the block decomposition, followed by remeshing of each block with either structured mapping or Pave-and-sweep.

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**Solution Verification and Mesh Scaling**

The model simulates weld failure from thermal/mechanical loading. The main output is the maximum equivalent plastic strain (EQPS), an indicator of weld failure.

**Future Research:**

Calling the Paver to remesh swept blocks is the weak link in the current mesh scaling algorithm. Paving:
- Results in unpredictable structure and quad count
- Inherently serial, can not scale to HPC
- No guarantee of certain number of layers through thin sections

We have prototyped a new “Hybrid” method to mesh scaling:
- Modifies original mesh with strategic dicing and smoothing
- No Paver
- Maintains number and type of singularities → structure
- Parallelizable
- Can guarantee certain number of layers through thin sections