Contribution to GMGW-1

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- PID 23

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Overview of Approach.

Mesh quality

- Grid Pro
- ICEM CFD HEXA
- Pointwise
- Hypermesh
- Ansa
- This is where we need to go

minimum acceptable
grid quality

- CCM+
- Boxer
- Snappy Hex

CAD entities/human time
Geometry Import and Preparation

Our approach for this project

Practical end-user approach

Developer
User

Run mesher
Fix Problems
Trailing Edge/Wake treatment

• Initially regarded wake as essential
• Modeled wake shape with panel code.
• Shape was too irregular.
• Wanted to have a structured anisotropic surface mesh on blunt trailing edge.
• Could not do a good job matching element volumes from top and bottom surfaces.
Mesh Generation from the human standpoint

• Select the part/import.
• Build the far field.
• Click repair button.
• Enter meshing parameters.
  • SAG/refinement number
  • Max Size
  • Min Size
  • Number of layers
  • Initial Height
  • Growth ratio.

• Click “mesh”.
Ennova is built around the idea that grid generation needs to be automatic/scalable.

- First customers are car companies doing simulations from final CAD data (not concept). (100,000’s of CAD surfaces).
- Working with GE on a combustor for a gas turbine with 10,000 solids, 250,000 CAD surfaces.
- Human effort cannot scale with number of CAD surfaces.
- Built around client/server to access:
  - Most memory CPU power. (It is far faster to run server in Berkeley on 8 CPU linux box talking to laptop, rather than having server on laptop).
- Security
- IT administration.
- Licensing cost.
Summary of grids generated:

<table>
<thead>
<tr>
<th>Case</th>
<th>Code(s)</th>
<th>Starting Geometry Model</th>
<th>Grid Type</th>
<th>Number Grid Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>HL-CRM full gap</td>
<td>Ennova</td>
<td>Parasolid</td>
<td>Unstructured Tet/Prism</td>
<td>1</td>
</tr>
</tbody>
</table>
Geometry Import and Preparation

• Problems encountered.
  • With some of the surfaces the number of triangles in used for the display of the surfaces was large. There was a bug in the data compression from the server to the client that messed up the display of those surfaces.
  • Display/search triangulation was too coarse where flap geometry wrapped around near itself. Nodes jumped to the wrong side.

• Describe modifications performed on the geometry
  • User did no modifications.

• Lessons learned
  • Geometry import/repair was relatively strong.
Mesh Topology

• Has all connectivity data no geometry.
• Face is an Ennova constructed entity vs. Surface is an original CAD entity.
• Edges (composite/intersection) vs. Curves

• CAD data is read only. Held in original format
  • B-splines
  • STL
  • conics.
  • Search/display triangulation.

• Geometry queries performed by our own kernel.
  • If it doesn’t work we can fix it.
  • Thread safe/efficient.
Mesh Generation from the computer’s standpoint

• Stitch
• Volume finding.
• Defeature
• Sizing
  • Proximity refinement
  • Size similarity across gap
• Face mesh generation.
  • Parallel (5 million element surface mesh 10 minutes 8 CPU machine).
  • Multiple backup approaches.
  • Curvature based refinement.
Mesh Generation from the computer’s standpoint

- Difficulties encountered
  - Models that we are accustomed to working with have 100,000 CAD surfaces and fewer elements/surface.
  - CRM model had > 250,000 triangles/face.
  - Initially 4 hours, later 10 minutes.
Mesh Generation

• Difficulties encountered
  • When there was a global min size and a group min size the edges might pick up the wrong value
Mesh Generation

- Difficulties encountered
  - Prism layers were dying at trailing edge.
Not flatworm

Existing code to make sure there were enough nodes in this case.

Was putting too many nodes on edges in this case.
Mesh Generation

• Timing
  • Prism meshing takes time, but is also parallel so will benefit from more processors
  • Tet meshing is far too slow and is still serial.

<table>
<thead>
<tr>
<th>Import</th>
<th>Cleanup</th>
<th>Controls parameters</th>
<th>Surface mesh generation</th>
<th>Boundary Layers</th>
<th>Tetra meshing</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 minute</td>
<td>??</td>
<td>5 minutes</td>
<td>10 minutes</td>
<td>10 Hours</td>
<td>10 Hours</td>
</tr>
</tbody>
</table>
# Mesh Statistics

<table>
<thead>
<tr>
<th>Geometry Model</th>
<th>Grid Type</th>
<th>Grid Level</th>
<th>Nodes</th>
<th>Boundary triangles</th>
<th>Prisms</th>
<th>Tetraheda</th>
<th>Triangle Quality</th>
<th>Criteria 2</th>
<th>Criteria 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLCRM-Full Gap</td>
<td>Ustructured Tet/prism</td>
<td>Coarse</td>
<td>38 M</td>
<td>4.8M</td>
<td>100 M</td>
<td>20M</td>
<td>.044</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Feel free to use histograms or other chart types to present statistical data.
Surface Mesh Wing Lower Surface
Surface Mesh - Wing Slat LE at Root
Surface Mesh - Wing Flap TE at Root
Surface Mesh - Wing Tip LE
Surface Mesh - Wing Tip TE
Flap Gap Upper Surface
Tail
Nose
Volume Mesh Cut at y=277.5
Volume Mesh Cut at y=638
Volume Mesh Cut at y=1050
Mesh Evaluation

• Simply ran standard element quality checks.
  • When we got bad quality elements we went back and changed the code.
  • Removed several edges to unconstrain the mesh

• Adherence to meshing guidelines
  • No wake treatment
  • Did not make first two layers identical size.
  • Did unstructured mesh on trailing edge.
Additional Topics

• Future Technology
  • Trailing edge wakes.
  • Anisotropic 2D meshing.
  • Parallelize tet meshing
Summary

• What did we learn from this project?
  • Easy: Reading geometry, producing very simple mesh.
  • Hardest: Generating mesh to conform to guidelines.