GMSH Workshop: meshing

September 19, 2011

The information for doing this workshop can be found in the Gmsh wiki:
`https://geuz.org/trac/gmsh/wiki`

1 Remeshing a surface with parametrizations

We will first learn how to remesh discrete surfaces using Compounds (Lines and Surfaces). The remeshing algorithm is based on a parametrization of a 3D surface onto a planar surface. With this parametrization, we have now for each XYZ, a parametric coordinate UV in the planar space.

- Remesh the surface "reparamINPUT.msh" by creating as follows:
  `gmsh reparam.geo -2 -saveall` The saveall options is used in order to print some post-processing files for the parametrization.
- Open the resulting file `gmsh reparam.msh`. Using Tools>Visibility you can see the original surface with tag (5) and the remeshed surface with tag (10). If you wish to save only the remeshed surface you can define a physical surface in your geo file
  `Physical Surface(100)={10};`
- Open the created post-files:
  `gmsh UVX-5_0.pos  XYZU-5_0.pos  XYZV-5_0.pos` to see the parametrization.
- Compare a harmonic and conformal parametrization by changing the parametrization flag in the geo file: `Mesh.RemeshParametrization=0; //(0) harmonic (1) conformal`

2 Remeshing a STL file

We will see here how the remeshing algorithm improves the quality of the mesh.

- Load the stl `gmsh skullU.stl` and look at the mean quality of the elements. Tools > Statistics. Click on the update button and look at the quality of the elements by

clicking at Gamma (2D). Gamma is the elementary aspect ratio (the ratio between the inscribed and circumscribed radius, so that $\Gamma = 0$ is a flat degenerated triangle and $\Gamma = 1$ an equilateral triangle). You should see `0.7877 (0.003176->1)` which is: mean (min `->` max)

- Remesh the skull with the .geo file: `gmsh skull.geo -2`. The automatic option `Mesh.RemeshAlgorithm=1; //(0) nosplit (1) automatic (2) split metis` enables to remesh any kind of topological surface. Here the skull will be split by metis into different mesh partitions. All the mesh partitions and lines between the mesh partitions will be remeshed automatically using Compound Lines and Surfaces.

- Look at the mesh partitions created by the automatic mesh algorithm. `gmsh multiscalePARTS.msh`.

- Compare the mean and min mesh quality of the new triangular mesh (`gmsh skull.msh`). You should see for Gamma `0.9543 (0.01838->1).`

- Compare the quality for different 2D mesh algorithms. `Mesh.Algorithm=6;//(1=MeshAdapt,2=Automatic,5=Delaunay,6=Frontal,7=bamg,8=delquad)`

- If you want to create a volume with this new surface mesh you create a Volume by adding the three following lines:

```
Surface Loop(300)={200};
Volume(301)={300};
Physical Volume(502)={301}
```

  and create a volume mesh of the skull with : `gmsh skull.geo -3`

3 Cross-patch remeshing

Compounds can also be used to remesh groups of CAD patches together. This is very useful is some small CAD patches give rise to very small triangles. The CAD geometry of a car hood in .brep format

- Read the CAd model `gmsh capot.brep` and look at the small model edge (Tools > Visibility, see Lines 44 and 46)

- At first, try to mesh all patches individually. `gmsh capot.geo -2` Look at surface (15) to see the small element. (Tools > Visibility. Look also at the statistics. You will see the smallest element has $\Gamma = 0.007753$ which is quite bad for finite element simulations.

- Now create some Compound Lines and Surfaces that groups lines and Surfaces.

```
Compound Line(1000) = {47,50};
Compound Line(1001) = {44,46};
Compound Surface(100) = {1,8,15,17,16,18,9,2,3,10,7,14,11,4,12, 5,6,13} ;
Physical Surface(100)={100};
```

Do not forget the physical to keep only the new surface mesh (100).

- Look at the new mesh quality for this new mesh. There are no more small elements and you should find for the minimum quality $\Gamma = 0.6164$.
- If you wich to remesh the geometry with quads, you should add three lines in your geo file:

```
Mesh.Algorithm = 8; //(8=delquad) For the delquad algorithm creating right triangles
Mesh.RecombinationAlgorithm=1;// For the blossom recombination of triangles
Recombine Surface {100}; // To recombine the triangles of surface 100
```

- Look at the new quad mesh: `gmsh capot.msh`. For quads you should look at the quality Eta that is defined as : You should have $\bar{\eta} = 0.8785$. Compare the quality with and without delquad.

$$\eta(q) = \max\left(1 - \frac{2}{\pi}\max_k\left(\left|\frac{\pi}{2} - \alpha_k\right|\right), 0\right). \tag{1}$$

This quality measure is 1 if the element is a perfect quadrilateral and is 0 if one of those angles is either ≤ 0 or $\geq \pi$.

4 Quad mesh of a bmw car

For meshing an arbitrary geometry with quads, its is best to define patches with straight edges, so that the quads are aligned with those straight edges. Here, we will start from a stl of a bmw car and cut it by level sets (planes).

- First cut the stl file in different patches. The levelset cut tool is used in the .geo file to cut the stl by planes $Ax + By + Cz + D = 0$.

```
Levelset Plane (3) = {0.0, 1.0, 0.0,0.52 }; // A,B,C,D
Levelset CutMeshTri {3};
```

Create the cutted stl as follows: `gmsh bmw2.geo -2 -saveall`.

- Look at the cutted stl file: `gmsh bmw2_cut_cut_cut.msh` that contains now 7 different surfaces (Tools > Visibility)

- Remesh those 7 surfaces with quads using the combination : delquad+blossom. `gmsh bmwCUT.geo -2.`
  Look at the resulting mesh, the mirrors are quite unresolved.
- Refine the mesh size close to mirrors using the Mesh > Define > Fields. Choose New Box for each mirror and a New Min Field between box 1 and 2 and remesh it.