High Quality Surface Remeshing Using Harmonic Maps

C. Geuzaine[1], E. Marchandise[2] and J.-F. Remacle[2]

[1]Université de Liège, Department of Electrical Engineering and Computer Science, Montefiore Institute B28, Grande Traverse 10, 4000 Liège, Belgium, cgeuzaine@ulg.ac.be

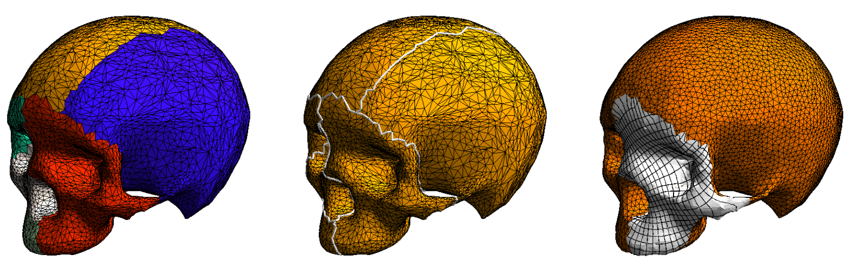
[2]Université Catholique de Louvain, Institute of Mechanics, Materials and Civil Engineering (iMMC), Place du Levant 1, 1348 Louvain-la-Neuve, Belgium

Creating high quality meshes is an essential feature for obtaining accurate and efficient numerical solutions of partial differential equations as it impacts both the accuracy and the efficiency of the numerical method using those meshes.

In many cases, surfaces do not have a standard CAD representation and are only known by triangulations such as stereolithography (STL) triangulations. These kinds of surfaces are commonplace in many areas of science and engineering, e.g. in the form of 3D scanned images, terrain data, or medical data obtained from imaging techniques through a segmentation procedure. Such triangulations are often oversampled and/or of poor quality (with triangles exhibiting very small aspect ratios), which makes them unsuited for direct use by numerical methods like finite elements, finite volumes or boundary elements. This is also problematic for the volume mesh since the surface mesh serves as input for the volume meshing algorithms. Improving the mesh quality can then be performed using a remeshing procedure.

In the case of manufactured objects, the surfaces are often designed using a CAD system and described through a constructive solid geometry procedure. Non Uniform Rational B-Splines (NURBS) are commonly used for describing the shape of surfaces. NURBS surfaces are usually nice and smooth so that it is possible to produce high quality surfaces meshes using NURBS as input. However, most surface mesh algorithms mesh model faces individually, which means that points are generated on the bounding edges and that these points will be part of the surface mesh. If thin CAD patches exist in the model they will result in the creation of small distorted triangles with very small angles—even if the bounding edges of these thin patches have no physical significance. As in the case of a poor quality STL triangulation, a remeshing procedure is then also desirable.

In this talk we will discuss a remeshing algorithm based on discrete harmonic maps [1] and show the solution strategies adopted for the remeshing of surfaces with large geometrical aspect ratio and arbitrary genus. We will present different examples demonstrating the usefulness of the method for remeshing triangulations coming from segmentation data with very poor element quality, and for industrial CAD-based surfaces that contain too many tiny surfaces, unsuitable for finite element computations.



a) b) c)

Figure 1: Remeshing algorithm for a skull geometry. a) Initial triangulation (G = 2, NB = 0), b) Remeshing of the lines at the interfaces between partitions, c) Computation of a harmonic map for every partition and remeshing of the partitions in the parametric space.

References

[1] J.-F. Remacle, C. Geuzaine, G. Compère, and E. Marchandise. High quality surface remeshing using harmonic maps. *Int. J. Numer. Meth. Eng.*, in press, 2010.