SIMPLIFICATION OF COMPOSITE PARAMETRIC SURFACE MESHES

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Surfaces can be defined essentially in two different ways for modeling objects in various application areas (graphics, finite element computation, etc). The first way consists in defining a set of conformal parametric patches, this approach being used in most CAD modelers. The second way consists in defining the surface using a mesh reconstruction method from a set of points belonging to the surface, as well as volumetric data. Our paper will focus on the first case, where a complex object can contain a large number of patches. By definition, a patch dependent mesher preserves the contours of each patch. Within the context of finite element computation, it is more convenient to reduce the number of mesh elements and to improve their shape quality, while preserving the geometry of the object. Mesh simplification methods allow us to respond to the above requests. There are generally based on the optimization of geometric criteria [1]. Let us recall that a mesh of a surface whose element vertices belong to the surface is geometrically suitable if all mesh elements are close to the surface and if the supporting plane of each mesh element is close to tangent planes of the corresponding surface. The first (proximity) guaranties that the mesh is an accurate approximation of the surface. The second (smoothness) ensures that the surface is G^1-continuous. An optimal surface mesh is a geometric mesh whose elements are regular or almost equilateral (which is an essential request for most applications).

We present a mesh simplification method based on the Hausdorff distance, in the particular context of composite parametric surface meshes. It consists, first, in defining a global tolerance envelope around the surface and a local tolerance cone centred at each vertex of the reference mesh of the surface, then in eliminating the edges of the reference mesh if the resulting elements belong to the tolerance areas. In fact, these areas allow us to ensure respectively the proximity and the smoothness properties. The simplified mesh can be optimized according to the element shape quality using edge swapping and point relocation procedures. Again, these operations are applied if the geometry is preserved. Given a patch dependent mesh of a composite parametric surface, this method is applied to each interface edge (connecting vertices between two different patches which are globally G^1-continuous). Indeed, these edges are constrained by the patch-dependent mesher and can violate the size mesh specification. To identify these edges from the sole data of the mesh, the normals at vertices must be given. Several examples show the relevancy of the method.

References

[1] P. Heckbert and M. Garland, “Survey of polygonal surface simplification algorithms”, *Tech. Rep. CMU-CS-95-194*, Carnegie Mellon University, 1995. http://citeseer.nj.nec.com/heckbert97survey.html.