An Interactive System for Robust Topological Modeling of Meshes

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The current computer graphics practice is almost exclusively based on polygonal meshes. To avoid artifacts such as wrongly-oriented or missing polygons, and T-junctions, the polygonal mesh must satisfy a mathematical property called 2-manifold. 2-manifolds are essential for most computer graphics applications. For instance, initial control mesh for subdivision schemes must satisfy 2-manifold property. A polygonal mesh that has a missing polygon can ruin the radiosity computation. In ray-tracing, a transparent shape with a wrongly-oriented polygon can cause unwanted artifacts in the resulting image.

Topological modeling of 2-manifold polygonal meshes has always been a difficult challenge in computer graphics. Our Doubly Linked Face List (DLFL) [1, 2] provides an effective solution to this challenge. DLFL always corresponds to a valid orientable 2-manifold polygonal mesh and provides a minimal set of operations to change the topology of 2-manifold meshes.

This sketch presents a prototype system to demonstrate the power of DLFL for the development of interactive polygonal mesh modelers. Users of our system can easily change topology (i.e. they can create and delete holes and handles, connect and disconnect surfaces). Our system also provides smoothing operations (subdivision schemes) to create smooth surfaces. Moreover, the system provides automatic texture mapping during topology and smoothing operations. Our system is topologically robust in the sense that users will never create invalid 2-manifold mesh.

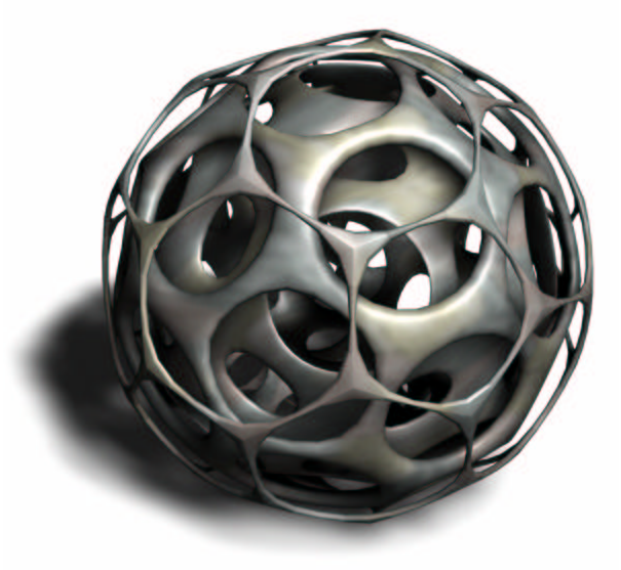

Figure 1: 2-Manifolds with high genus.

To demonstrate the effectiveness of the system, we have created various polygonal meshes that would be extremely difficult to model interactively without our system. The nested shapes shown here represents an example of models that can interactively be constructed using our system. The inspiration for this shape came from chinese sculptures consisting of a set of nested rotatable balls. The actual sculptures can have up to 16 nested balls. Our version consists of three surfaces with genera 31, 31 and 41, respectively.

Figure 2: A teapot created by using our system.

Creating holes and handles is not only useful for aesthetic purposes. In fact, the holes and handles are essential to construct functional models. The teapot shown in Figure represents an example of a functional model. As it can be seen from an x-ray image, this teapot has a real (not just a “look-like”) hole to let the water pour from the spout. Because of the hole in the spout, this teapot can be used in physical simulations. The hole in the spout and the handle are designed in our system starting from a few numbers of rectangular prisms.

References

[1] E. Akleman and J. Chen, “Guaranteeing the 2-Manifold Property for meshes with Doubly Linked Face List”, *International Journal of Shape Modeling* Volume 5, No 2, pp. 149-177.

[2] E. Akleman, J. Chen, and V. Srinivasan, “A New Paradigm for Changing Topology During Subdivision Modeling,” Pacific Graphics 2000.