Interactive Construction of Multi-Segment Curved Handles

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Abstract

In this work, we present a method to interactively create multi-segment, curved handles between two star-shaped faces of an orientable 2-manifold mesh or to connect two 2-manifold meshes along such faces. The presented algorithm combines a very simple 2D morping algorithm with a Hermite interpolation to construct the handle. Based on the method, we have developed a user interface tool that allows users to simply and easily create multi-segment curved handles.

1 Introduction and Motivation

This work presents a new modeling approach for interactively creating very high genus 2-manifold smooth meshes, based on creation of free-form handles. The method can be used for handle creation (i.e., adding a handle to a surface) and for surface blending (i.e. connecting two distinct surfaces). Both applications of the algorithm are useful to designers for creating manifolds of high genus.

A handle is not an extrusion (or lofting) and handle creation is not simply an extrusion method. Handle creation is a topological operation and it requires topological consistency. Therefore, handle creation methods are different than extrusion methods since they are required to guarantee topological consistency. Our method not only guarantees 2-manifold property of final mesh, in every stage of our handle creation costructed meshes continue to be 2-manifold.

The meshes constructed by our method can be smoothed by any subdivision scheme since the manifold property is preserved after handle creation. Figure 1 shows two views of a genus-6 shape created by our approach combined by subdivision schemes. To create this object, we first created 6 multi-segment curved handles by connecting pairs of neighboring faces of a dodecahedron, and then smoothed the resulting mesh using one iteration of the Doo-Sabin and two iterations of the Catmull-Clark subdivision schemes.

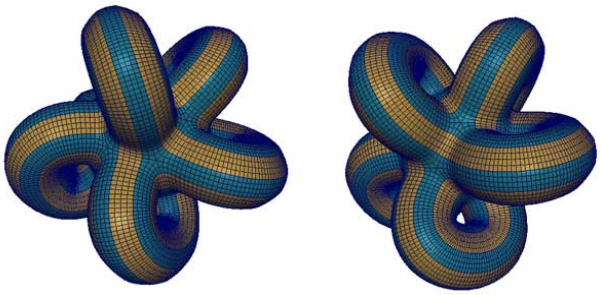

Figure 1. Two views of a genus-6 manifold mesh created by our approach.

Handle creation can also be applied after a subdivision operation, since most subdivision schemes also preserve the manifold property. As a result, subdivision schemes and handle creation operators can alternatively be applied to hierarchically construct high genus manifold meshes. An example of such a hierarchically constructed mesh is shown in Figure 2.

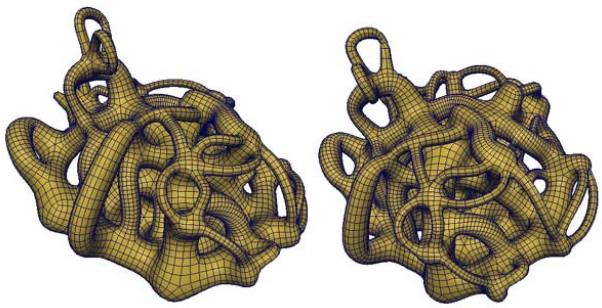

Figure 2. Two views of a manifold mesh created by alternatively creating handles and applying Catmull-Clark subdivision scheme.

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A prototype system for creating multi-segment curved handles was tested in a graduate level shape modeling course in which majority of the students had an architecture undergraduate background. An example of a shape created by the students is the high genus "Möbius band looking" shape shown in Figure 3 The student learned how to use the software and finished the model in one week. (Ant model was created earlier.)

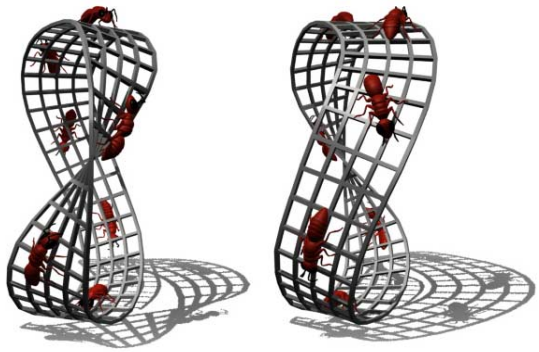

Figure 3. An homage to Escher: *Band Van Möbius II* **[5].**

The creation of very high genus smooth 2-manifold surfaces has always been a research interest in computer graphics and shape modeling. Akleman and Chen recently introduced a topologically robust mesh modeling approach to computer graphics and shape modeling [1] by adopting topological graph theory, a relatively obscure mathematical theory that was introduced almost 100 years ago and known by only a handful of graph topologists. They have shown that their method and subdivision schemes reinforce each other [2]. Their 2-manifold mesh modeling scheme is based on a minimal set of manifold preserving operators[1] [1] that is simple, intuitive and user-friendly.

It has recently been shown that their operators can be efficiently implemented on almost every mesh data structure including winged-edge and half-edge [4]. Based on this minimal operator set, a user interface is developed and user friendly high level operators to interactively model orientable 2-manifold meshes are introduced [3]. One of the most useful high-level operators is the CREATEPIPE operator [3].

The main problem with the CREATEPIPE operator is that the length of each edge in a handle can be much longer than other edges in the mesh $\mathcal{M}$, as shown in Figure 4B. In this paper, we present preliminary results which demonstrate a solution to this problem. Instead of one pipe segment to connect the two faces, we use a pipe with multiple segments. This pipe approximates a curve that starts from the centroid of the first face, in the direction of the face normal with a given magnitude and ends at the centroid of the second face in the opposite direction of the face normal with another given magnitude. The quality of the handle improves considerably with the new approach, as shown in Figures 4C and 4D.

[1]Patent pending.

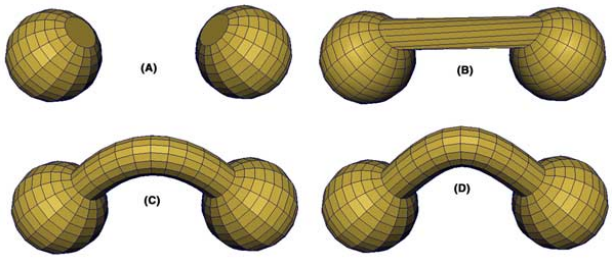

Figure 4. Problem of long edges and our piecewise straight solution. A is the original mesh, B was obtained using the CREATEPIPE **operator, C and D were obtained using our new approach with different weights for the normals in the Hermitian curve equation.**

References

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