Interactive Modeling with Mesh Surfaces

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Figure 1: *Mesh surface models created by a skilled artist. These results demonstrate the potential of combing adaptive mesh sculpting with novel composition tools and traditional operations such as extrusions, in a single interface. Such a system can easily incorporate raw scans as input (left), and relieve the tedium of creating repeated elements such as scales or teeth. Images © Gunter Weber.*

Abstract

In the world of modern surface design tools, a mesh is simply a data structure – a scaffold for higher-order basis functions which specify the “true” surface. The price paid for this analytic continuity is complexity in seemingly-simple tasks such as refinement, composition, and direct manipulation. But consider the lowly triangle mesh. With the ability to split and merge edges wherever more detail is needed, or stitch and sew arbitrary boundaries, unstructured high-resolution triangle meshes bring us much closer to the ideal of modeling at the level of *surfaces* rather than *data structures* (as has been previously noted [Welch and Witkin 1994]).

Despite this potential, however, practical systems for interactive design of such *mesh surfaces* have so far failed to materialize. In the process of attempting to create such a tool, I have found that the interface poses more challenges than the algorithms. Techniques suitable for low-resolution cage-style meshes, such as picking and manipulating individual vertices, are often of little use when faced with millions of elements. Many recent works have framed such problems variationally, from “magic” selection to robust detail-preserving global deformation. Though powerful, these techniques often do not address many of the smaller challenges that a 3D artist faces on an hourly basis. Sculpting tools [Stanculescu et al. 2011] provide another sort of abstraction, though tend to be focused on certain styles of organic design.

In this talk I will present a general-purpose mesh modeling tool, called *meshmixer*, which draws on many of these existing works. The models in Figure 1 demonstrate what is possible with the *combination* of sculpting, traditional surface modeling, and advanced variational methods, in a unified mesh surface design interface. With a sufficiently expressive toolset, solutions to many problems take the form of simple *workflows*. For example, a brush-style face selection tool followed by a surface-constrained smoothing of the selection boundary loop results in smooth feature curves useful for further operations such as extruding and cutting holes.

Composition tools are a particular focus of meshmixer, as this is one capability of mesh surface modeling difficult to replicate with more structured analytic surfaces. In addition to drag-and-drop part composition [Schmidt 2010], tools are included to both manually and automatically zipper the boundaries of mesh patches. The novel, robust, and easy-to-implement algorithm which drives these zippering tools has also been applied to implement mesh booleans and precise cutting operations.

Adaptive meshing is a foundational concept applied throughout meshmixer, from sculpting to Booleans. The goal is to allow the artist to focus on managing shape rather than triangles – ideally making “wireframe” renderings unnecessary. In addition, I have found that mesh adaptation simplifies many algorithmic tasks, such as the zippering mentioned above. But in an interactive context mesh adaptation introduces various scalability issues. I will describe my progress so far in addressing these problems.

The freely available Meshmixer software is in daily use by working artists and designers. An extensive body of feedback is being actively collected and used to guide interface design decisions. This feedback also exposes the limitations of many of the current tool implementations in Meshmixer, and can provide some motivation for future research.

Ultimately, the goal of such a system is to provide an unconstrained surface manipulation interface which insulates the designer from the technical details of the underlying mesh. Meshmixer takes several steps towards this goal. The results created by artists using this tool clearly demonstrate the potential of mesh surface modeling for 3D design.

References

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