SIMPLIFYING TETRAHEDRAL MESHES WITH SCALAR DATA FIELDS[1]

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A great many modern applications make extensive use of spatialized data both scanned from the physical world and produced by simulation. Scientific and engineering simulations produce many very large data fields. Medical scanning devices in widespread use (e.g., MRI) are used to acquire detailed data about patients. Even the entertainment industry relies heavily on advanced physical simulations, such as fluid dynamics for movie special effects. The amount of data produced in these application domains is often substantially more than is required in any one intended use. Similar problems resulting from automatic surface acquisition have spurred significant effort directed towards the automatic simplification of surface meshes. However, there has been comparatively much less work devoted to the problem of simplifying data fields.

We have developed a new method for automatically simplifying tetrahedralized data fields. Our method accepts tetrahedral meshes (of arbitrary topology) having any number of data fields defined by per-vertex scalar values. The result is an approximation consisting of a coarsened mesh and per-vertex approximations for each of the constituent data fields. At the heart of our approach is a greedy iterative contraction framework, driven by a novel generalization of the quadric error metric [1], which has proven very effective in the domain of surface simplification.

The result is a system that can efficiently simplify tetrahedral meshes while producing high quality approximations. Figure 1 shows an example of a dataset containing 616,050 tetrahedra and 5 scalar fields being reduced to 5.8% of its original size in just under 3.5 minutes on a modern PC. Looking at the fluid density field shown, we see that fine details of the field are preserved even in the coarsest approximation. Volume approximation of this sort enables a variety of important applications, including level of detail control for real-time rendering, lossy data compression, and progressive network transmission.

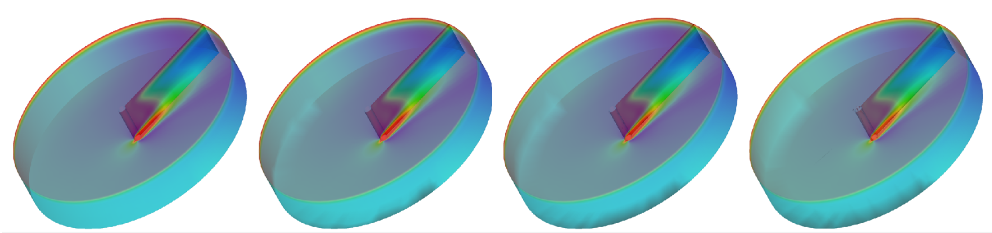

Figure 1: One of five fields resulting from CFD simulation simplified to 5.8% of original size.

References

[1] M. Garland and P. S. Heckbert, "Simplifying surfaces with color and texture using quadric error metrics," *Proceedings of IEEE Visualization 98*, pp. 263–269, 1998.

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