A Fast Hybrid Geomorphing LOD Scheme

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We present a new technique for fast, view-dependent, real-time visualization of large multiresolution geometric models with color or texture information. This method combines the rendering speed of optimized static models, the smooth transitions associated with geomorphing, and the viewpoint adaptivity of iterative vertex contraction based methods.

1 System overview

A significant amount of recent work on real-time multiresolution rendering of triangulated geometric models is built on the concept of iterative edge contraction(e.g. [Hoppe 1997]). The system we have developed is a hybrid method that integrates aspects of this kind of approach and of more classical discrete Level of Detail (LOD) techniques. Our goal was to produce a multiresolution rendering system that would produce minimal visual artifacts when rendering high resolution scene or object datasets produced from sensor data while maintaining the same graphic performance we get with optimized static versions of those models.

The first step of the method is to partition the triangular mesh into a set of groups. The model is then globally decimated into a series of discrete LODs using an algorithm based on vertex pair contraction. Each discrete level is repartitioned along the same boundaries. Groups are shaped based on criteria such as compactness, orientation, texture, and desired granularity.

At run-time, LOD levels and geomorph ratios between selected levels are computed for each group of the model, these groups are then rendered as precomputed triangle strips. Border points between groups are geomorphed in order to maintain seamless continuity between neighboring LOD groups at all time. To achieve this, we maintain a connexity graph between the various groups and apply a set of simple rules when morphing these points. Morphing is done for space and texture coordinates, normals and color.

Adjusting the granularity of the multiresolution rendering through this grouping process provides us with multiple advantages. First, it allows us to extend smooth geomorphs over numerous frames by morphing more triangles over a longer distance rather than expanding/contracting the model by a few polygons every frame. Secondly, each group having a static topology, it can be efficiently rendered as a set of pre-computed triangle strips. These groups can also serve as the units of an anticipative paging algorithm for larger models. Finally, groups can be shaped so that they correspond to rectangular texture images, therefore optimizing texture memory usage and smoothing texture swapping for high resolution models.

2 Results

Our current implementation uses quadric error metrics[Garland and Heckbert 1998] to decimate the models and SGI's OpenGL Performer as the base of the run-time infrastructure. The multiresolution processing is done asynchronously on a different CPU than the one used for rendering. We tested our method on various colored or textured models produced using range sensors and digital photographs. Our test system was a 1.4 GHz dual Athlon PC with a GeForce 4 graphic card. The figure shows a slanted view of a rectangular cuneiform tablet to illustrate the similar pixel size of the triangles at different distances from the observer. The model is textured and varies in size from 25k to 2.5M polygons. The tablet, scanned using the National Research Council's color range sensor, was provided by Prof. Marc Levoy of Stanford University while it was on loan from Renee Kovacs.

During those tests, the time required to perform the LOD selection and the morphing of all visible triangles (geometry, color/texture and normals) on one of the CPUs amounted to roughly 30% of the time required to render the corresponding frame, allowing free cycles for other processing. The number of rendered polygons per second was the same for a static model loaded with Performer's viewer and for its multiresolution counterpart loaded with our application. This confirms that there is no graphic penality associated with the multiresolution processing, therefore allowing a maximal frame rate increase. Also, as expected, this method produces almost unnoticeable transformations during LOD morphing, and produces especially good results with textured data.

We are currently implementing the anticipative paging and compression strategy that will allow navigation through larger models. We are also pursuing work on automatic segmentation of the models, on recursive subdivision of the groups, and we are implementing more advanced LOD selection criteria based on both resolution and frame rate constraints.

References

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