Constructive Solid Geometry

A technique used to create complex three-dimensional geometric shapes by applying Boolean operations on primitive shapes.

This project tests the hypothesis that CSG can be rendered quickly and with good image quality by suitably creating and using three-dimensional texture maps.

Three Dimensional Texture Mapping

The texture map contains voxels storing opacity information: voxels outside the model have alpha values of zero (transparent) and voxels inside the model have alpha values of one (opaque).

Sampling Line Tracing

By tracing sampling lines through the CSG model, we can easily identify which voxels are transparent, which voxels are opaque.

Positive and Negative Surfaces

To improve the image quality, we shrink triangles of surfaces that are inside the model (positive surfaces) and expand triangles of surfaces whose complements are inside the model (negative surfaces).

Sampling Line Sharing

Sampling lines are traced along edges, faces, and through the centers of columns of voxels, allowing sampling lines to be shared between adjacent voxels.

Quad Tree

Columns of voxels are grouped into nodes of a quad tree in the dimensions perpendicular to the columns. This grouping allows us to quickly identify tree nodes that do not contain any primitives and therefore do not need to have sampling lines traced through their voxels.

Results

We evaluate the image quality of Volumetric CSG and measure its preprocessing time in comparison with Triangle Subdivision, an alternative technique to volumetric CSG. In conclusion, Volumetric CSG shows great improvement on preprocessing time and produces reasonable image quality. In the future, we want to further improve the image quality produced by Volumetric CSG and characterize its rendering speed.