Tetrad Volume and Particle Rendering in X2

Bill La Barge* Jerry Tessendorf† Vijoy Gaddipati‡
Cinesite Digital Studios

1 Motivation

In the movie X2, Cerebro is a large spherical cavity that extends mutant mental capabilities. To depict its large, cavernous, dynamic nature, and the connnection between the machine and the characters, the atmospheric element of the scene was built based on a fully 3D volumetric rendering technology developed at Cinesite. In addition, this volumetric technique was also used to connect floating vinnettes in the space with the land masses on the borders of Cerebro.

The teleportation effect of the character Nightcrawler is accompanied by a dynamic smokey filament effect using turbulent particle dynamics and particle rendering.

2 Tetrads as Volume Elements

Volume rendering is usually based on some form of ray marching or casting into a rectangular volume that is subdivided into rectangular voxels. Such a regular array is limited in spatial resolution to the resolution that is achievable within the regular grid. For example, grids with dimensions of about 1000x1000x1000 are possible with considerable memory and computation time resources. For production purposes, we needed a volume representation that allows very detailed structure while keeping memory usage very low and computation time as low as feasible. The VoxelB [1] approach used at Digital Domain provides interesting structure in the volume via interactive feedback, but still requires very large memory resources for the detail we wished to achieve. An alternative implicit surface method [2] was used to dynamically voxelize regions of a volume as they were needed. This method kept the memory resources lower, but the rendering time would still be large for the amount of detail desired.

In our approach we chose instead to represent the fundamental volume element as a tetrahedron (tetrad), i.e. a three sided pyramid constructed from four points in space. There were several reasons for this: (1) tetrads are the simplest completely volumetric object that can be built - three points in general define a plane in space, so four points are the minimum number needed to describe a volume; (2) no matter how the four points of a tetrad are placed relative to each other, they still form a tetrad with relatively simple structure and well-defined and oriented faces; and (3) tetrads with a long aspect ratio were easily used to create the impression of energy transfer and sunbeams.

3 Tetrad Generation

A two-step process was developed to generate and control the distribution of tetrads throughout the rendering volume. The first step is the generation of guide particles. These particles, along with their attributes, were written as PDB files from Maya for subsequent multiplication and rendering.

The second step occurs inside the renderer developed at Cinesite. The renderer handles one guide particle at a time. For various types of distributions desired, ”emission shaders” based on a general purpose c-parsing language were written to procedurally multiply each guide particle into many, typically in the range of 5-50 children each. Using additional vertex information from the PDB files the renderer generates either tetrad volumes or spherical particles.

*bill@cubehost.net
†jerryt@rhythm.com
‡vgadu@yahoo.com

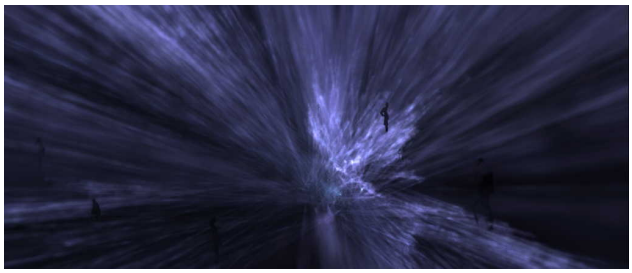

Figure 1: Example of a volume rendered element using tetrads as the basic volume element.

4 Rendering

Rendering of particles and tetrads was accomplished with Cinesite’s proprietary renderer *partman*[3], which is a high precision renderer of spheres and tetrads, with a statistically-based z-buffer procession for occlusion. This produces images of enormous concentrations of particles or tetrads in tiny memory footprints.

Each child tetrad is rendered using an analytic formula for the volume rendering through a finite segment of uniform medium. The color and opacity are procedurally modified from point to point in a volume shader based on the same c-parsing language and standard noise functions. The renderer is able to render single tetrads at a time and properly accumulate the effect of the many tetrads, keeping memory usage low.

5 Conclusions

The unique nature of the Cerebro scenes in X2 were a perfect proving ground for new volume rendering techniques based on tetrahedral objects as the fundamental unit of volume. The smokey filaments required for Nightcrawler’s teleportation were a good opportunity to explore new methods of particle dynamics and rendering. Both forms of rendering – tetrad volumes and particles – were accomplished using a specialized proprietary renderer developed by Cinesite Digital Studios.

6 References

1. Alan Kapler and Lucio Flores, ”Evolution of a VFX Voxel Tool”, Sketches and Applications, Siggraph 2002.

2. Gokhan Kisacikoglu, ”The Making of Black-Hole and Nebula Clouds for the Motion Picture ”Sphere” with Volumetric Rendering and the F-Rep of Solids”, Sketches and Applications, Siggraph 98.

3. Jerry Tessendorf, ”Efficiently Rendering Gobs and Gobs of Particles”, unpublished notes, May, 2002 (included in the proceedings cd-rom).