Research on Real-Time Multi-dimensional Rendering Method of Fluid Phenomenon in Large-Scale Virtual Scene

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Abstract. The real-time visualization of multi-dimensional spatial data of fluid phenomenon has always been a big issue. As to these temporal data, this paper provides a multi-dimensional rendering method for grid data of regular three-dimensional space—dynamically partition projection. This method generates fluid space LOD dynamically through combining the idea of direct volume rendering and imposter technology, and then realizes the real-time scheduling of temporal space data rendering that based on temporal series. Experimental comparison shows that the method in this paper can reflect the relation between project and its order correctly and efficiently, and it can achieve real-time multi-dimensional visualization of fluid phenomenon in large-scale virtual scene.

Keywords: Real-time multi-dimensional rendering, fluid phenomenon, large-scale virtual scene, dynamic LOD generation, contaminative gas diffusion simulation.

1 Introduction

Generating smoke, contaminative gas, running water and other dynamic phenomena and objects in virtual three-dimensional scene has always been one of the most challenging research directions. The shapes of fluid phenomenon are irregular and uncertain, so they always have vague boundaries, and it is difficult to use a fixed formula to make qualitative description of their external shapes. Furthermore, since they are changing constantly, the complex variation makes the classical Euclidean geometry useless in their description, and rendering based on point, line, surface, volume (2.5 D) and other primitive in traditional computer graphics can not describe their evolution effectively.

In the field of spatial information, the representation of fluid phenomena is also based on the location representation, or using 2D to show its spatial area coverage [1]. There are no three-dimension or even multi-dimension visualized representation existing. In the research field of Computer Graphics and Visualization in Scientific Computing, there are lots of research fruits in three-dimension or multi-dimension.
rendering of the smoke, running water, cloud and other phenomena based on volume rendering algorithm[2-5]. In the field of virtual reality, the realization of visualization of smoke and fog is mainly based on the particle system [6-8]. However, most of them only describe the phenomena of small range with large calculated amount, which have serious influence on the real-time rendering. Many problems will emerge in the combination of single experimental environment and large-scale virtual scene. In the virtual environment, the real-time interaction between scene and other objects will be involved. Furthermore, it should meet the requirements on visual correctness (such as blocking relation), observation in any angle, real time, etc. Besides, the large scale of spatiotemporal data in fluid phenomena brings some difficulties in the limited hardware environment and real-time rendering.

Taking contaminative gas as an example, the new rendering proposed by this paper---dynamic partition projection does the multi-dimension (three dimensions + time) dynamic rendering addressing temporal order data of three-dimensional space field in contaminative gas diffusion process. It will show not only the internal spatial attribute of the contaminative gas, but also its evolutionary process, realizing the multi-dimensional dynamic visualization of real-time contaminative gas diffusion phenomena in virtual environment.

2 DYNAMIC Multi-dimensional Rendering of Real-Time

For the regular three-dimensional spatial data field rendering, there are 4 typical and frequently-used algorithms: ray casting, splatting, shear-warp, and the three-dimension texture mapping based on hardware. Volume rendering technique is suitable for the rendering of cloud and fog, providing the solution for vivid visualization of fluid phenomena. When it is adopted in the rendering of cloud and fog, the volume rendering technique is conducted in the targeting experimental environment in most cases. And in the virtual scene environment, the real-time interaction between scene and other objects will be involved. Furthermore, it should meet the requirements on visual correctness (such as blocking relation), observation in any angle, real time, etc. The existing rendering still has some problems in these aspects. Therefore, we put forward the dynamic partition projection to realize the real-time multi-dimension dynamic visualization for the fluid phenomena in virtual environment. Later, we will conduct the visualization experiment in contaminative gas diffusion by normal rendering and dynamic partition projection, and make comparisons between them.

2.1 The Basic Idea of Dynamic Partition Projection

Drawing from the combination of volume rendering algorithmic thoughts and imposter technique, the dynamic partition projection organizes the three-dimensional spatial data field to draw the visualization rendering in line with regular 3D grid way. The basic idea of it is that: first, redraw the data field in accordance with screen resolution or range of visibility (as Fig. 1), readjusting and generating dynamically the