Accelerate Volume Splatting by Using Run Length Encoding

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Abstract. Methods such as splat hierarchies, indexing and lists have been presented by the research society in recently years, to accelerate the splatting, a popular volume rendering algorithm. In this paper, a run length encoding (RLE) accelerated, pre-classification and pre-shade sheet buffer volume splatting algorithm is presented, which can enhance the speed of splatting without trading off image quality. This new technique saves rendering time by employing RLE mechanism so that only voxels of interest are processed in splatting. RLE based data structures are defined to exploit spatial coherence of volume and intermediate rendering images. A fast and accurate sheet buffer splatting method is used in the rendering process, which accelerates the splatting by traversing both the voxel scanline and the image scanline in sheet buffer simultaneously. Experiments practice proves that RLE can efficiently skip over transparent voxels in splatting and high speedup can be obtained by using the proposed algorithm.

1 Introduction

Volume Rendering [2] has been a new branch of computer graphics and an important visualization technique in recent years. It has gained great popularity in the comprehension and visualization of volumetric data sets from medical imaging devices such as computer tomography (CT), magnetic resonance imaging (MRI), ultrasound, positron emission tomography (PET), single photon emission tomography (SPET) and scientific simulations such as computer fluid dynamic (CFD).

A number of volume rendering algorithms such as volume ray casting [3], splatting [5] [6], shear-warp [7], and frequency domain methods [8] have been presented by the research society in the past two decades. Splatting proposed by Lee Westover [5] is an object-order traversal algorithm. In this algorithm, the voxels are sorted slice by slice in the front-to-back or back-to-front order. Traversed in the order, each voxel is classified by using a proper transfer function, and shaded by a given illumination model. Then, the voxel is projected into the image plane, and its contribution is accumulated to an image buffer using a

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projected reconstruction kernel called footprint. In this way, successive slices are composited to produce the final image.

Generally, there are two important software optimizations to accelerate volume rendering algorithm. One is early ray termination, which is most easily implemented in a ray caster. In this method, the algorithm traces each ray in front-to-back order and terminates when the accumulated ray opacity reaches a threshold close to full opacity. Any additional voxels reached by the ray are occluded, so they need not be rendered. The other is coherence acceleration using spatial data structures in which transparent voxels are skipped and only non-transparent voxels are considered in contribution to the final image. Because typical classified volumes have only 5%-30% percentage of non-transparent voxles [3] , and the computational cost is linearly proportional to the size of the voxels rendered in splatting algorithm, high speedup can be obtained by using an efficient spatial data structure.

Several algorithms are proposed to speed up volume splatting. Laur and Hanrahan [9] use a pyramidal volume presentation to improve the speed of splatting. Given transfer function and view-independent shading functions, an octree is constructed in which each node contains the average RGBA value of all its children and a value indicating the average error associated with the average. Then, the octree is traversed in a viewing order to splat the voxels, depending on the given allowable error that determines the refinement of rendered images. This algorithm does reduce rendering costs, but trades off image quality. Ihm [10] demonstrated a simple but efficient technique to speed up splatting by using indexing techniques. In this method, a sequence of pointers corresponding to a particular density value in one slice is enumerated in the increasing order of density values. The pointer associated with one density is a data block that keeps the position offsets which have the density value. In the rendering process, one can easily visit only voxels with values of interest by binary search of density values that are between required ranges of density values. This method can efficiently exploit spatial coherence and gain high speedup. One trivial disadvantage is that the algorithm requires much extra memory.

RLE based data structures used in Lacroute's shear-warp algorithm [7] has been proved a successful data structure, which accelerates the rendering process by efficiently skipping over transparent voxels. However, RLE based method is traditionally difficult to be applied in object-order volume rendering algorithms. In this paper, we propose a RLE accelerated, pre-classification and pre-shade sheet buffer based volume splatting algorithm. By employing RLE based data structures, together with a sheet buffer based splatting rendering process, the new algorithm can obtain high speedup without trading off image quality.

2 Basic Algorithm

Our algorithm consists of four steps, as shown in Fig. 1, pre-classification of raw density volume, pre-shade, run length encoding of classified volume, and sheet-