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GPU-based Object-Order Ray-Casting for Large Datasets

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Abstract

We propose a GPU-based object-order ray-casting algorithm for the rendering of large volumetric datasets, such as the Visible Human CT datasets. A volumetric dataset is decomposed into small sub-volumes, which are then organized using a min-max octree structure. The small sub-volumes are stored in the leaf nodes of the min-max octree, which are also called cells. *The cells are classified using a transfer function, and the visible cells are then loaded into the video memory or the AGP memory. The cells are sorted and projected onto the image plane front to back. The cell projection is implemented using a volumetric ray-casting algorithm on the GPU. In order to make the cell projection more efficient, we devise a propagation method to sort cells into layers. The cells within the same layer are projected at the same time. We demonstrate the efficiency of our algorithm using the Visible Human datasets and a segmented photographic brain dataset on commodity PCs.*

Categories and Subject Descriptors (according to ACM CCS): I.3.3 [Computer Graphics]: Picture/Image Generation I.3.7Computer GraphicsThree-Dimensional Graphics and Realism

1. Introduction

High resolution CT data is highly demanded by many current medical applications. The typical size of contemporary clinical 16bit CT data is about 256MBytes ($512^3 voxels$). The photographic volumetric datasets have color information, which are usually larger than the CT and MRI datasets of the same resolution. Moreover, the size of datasets will likely keep increasing at a high rate due to the advance of scientific devices. The rendering of large volumetric datasets is a classical problem in visualization.

Algorithms for direct volume rendering generally fall into two categories: image-order algorithms (e.g. ray-casting [Lev90]) and object-order algorithms (e.g. splatting [Wes90] or shear-warp [LL94]). The ray-casting algorithm can produce high quality images, and can achieve an interactive rendering speed using graphics hardware. Unfortunately, it imposes limits on the size of volumetric datasets that we can render at adequate update rates, because most state-of-the-art graphics cards only have 256 MBytes video memory. Real-time rendering of large datasets larger than 256 MBytes using the image-order algorithm is currently infeasible unless super-computers [PSL*98, KMM*01] or PC clusters [MOM*01, SMW*04] are used.

Volumetric datasets used in a variety of fields usually contain many regions that are classified as transparent or empty. The object-order approaches are well-suited for skipping empty regions, but usually the associated filters are too complex to be used for interactive rendering. And the hidden volume removal is also inefficient compared with the ray-casting method. Mora et al. [MJC02] proposed a CPU-based object-order ray-casting algorithm to take the advantages of both image-order and object-order approaches for interactive high-quality volume rendering. However, the cell projection implemented in this method can be efficiently performed only in orthogonal projection.

This paper presents a GPU-based approach for rendering large volumetric datasets on the commodity computers. A volumetric dataset is decomposed into small sub-volumes called *cells*, which are organized using a min-max octree structure. The cells are classified as empty cells or non-empty cells. The non-empty cells are loaded into the video

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