Hardware-Accelerated Particle-Based Volume Rendering for Multiple Irregular Volumes

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Abstract. In this paper, we propose a performance improvement of particle-based volume rendering (PBVR) by using a current, programmable GPU architecture. PBVR allows to render without visibility sorting by representing a given volume dataset as a set of opaque and emissive particles. In our new GPU acceleration of PBVR, we provide a switchable rendering pipeline that is compatible with both regular and irregular grid volumes. Particle generation is improved by using a cell-by-cell approach for processing large volume dataset. We also reduce the memory cost required for storing all sub-pixel values by proposing a pixel-superimposing technique targeting a large sub-pixel level. Our work demonstrates a full detail rendering rate from 5 to 11 fps for overlapped or separated multi-irregular volumes with a mega-scale number of volume cells on NVIDIA Geforce 8800GTX.

1 Introduction

Numerical simulations based on Finite Element Methods (FEM) such as Computational Fluid Dynamics (CFD) and Computational Structural Mechanics (CSM) commonly use irregular volumes in the form of mesh structures, such as tetrahedral meshes. Continuous advances in computer hardware, as well as in software technology, have increased the scale and complexity of these numerical simulations, generating large datasets to be analyzed. Scientific visualization is a proven, effective technique for extracting meaningful information from these datasets, and obtaining an efficient visualization method for large irregular volumes is currently one of the major research goals in the scientific visualization community.

High performance computing calculates a large FEM model that cannot reside in a single computational node and is distributed between multiple computational nodes. To evaluate whether the computation has been done successfully or not, a fast previewing is necessary. For previewing such a volume dataset, a volume rendering technique is suitable since the whole volume space can be visualized. Splatting may be used for this purpose, but it requires visibility sorting in which all the volume cells need to be processed in advance at each viewing point. In this regard, our particle-based volume rendering (PBVR) technique is suitable for previewing a huge irregular volume dataset since it requires no visibility sorting process. The technique represents a given volume dataset as a set of particles which are emissive and opaque based on a particle model from which Sabella's density emitter model [1] is derived. Once a vo-