A Scalable Hardware Architecture For Parallel Volume Rendering

Shin-ichiro Mori, Satoshi Yamauchi, Fumiyasu Harase, and Shinji Tomita

Grad. School of Informatics, kyoto University, Japan

Abstract

This paper propose a real-time volume rendering hardware for both perspective and parallel projections with the scalability beyond 512^3 volume.

CR Categries and Subject Descriptors: I.3.1 [COMPUTER GRAPHICS]:Hardware Architecture — Parallel processing

Additional Keywords: volume rendering, perspective projection, parallel processing, scalable architecture

1 INTRODUCTION

The demand for the large data visualization requires the scalable solution to realize real-time visualization. Here we propose a scalable hardware architecture for parallel volume rendering. The goal of this architecture is the real-time volume rendering for both perspective and parallel projections with the scalability beyond 512^3 volume[4]. The fundamental rendering algorithm used in this architecture is the Ray Casting Voxel Parallel algorithm like Cube3[1]. To achieve the goal of the scalable real-time rendering, we have simplified the sampling method and composition network.

2 ARCHITECTURAL FEATURE

2.1 Sampling Method and Parallel Volume Memory

Instead of sampling voxels on a ray at regular intervals of the ray itself(Fig.1(a)), we sample voxels at regular intervals of the ray's principal-axis which is the x,y, or z-axis most parallel to the ray(Fig.1(b)). Therefore, if the sampling interval is equal to the unit of the volume coordinate system, the coordinates of any sampling points with respect to the principal-axis are different each other. This makes it possible to construct a back-conflict free parallel volume memory for both perspective and parallel projections(Fig.2). Here, the principal-axis of each rays varies among x-,y-, and z-axis according to the view point and we want to avoid coordinate transformation in the memory to keep real-time follow-up to view point movement. So, we slice the volume space into planes perpendicular to x-, y-, and z-axis and store a set of i-th planes from Xplanes, Yplanes and Zplanes into i-th Parallel Treble Volume Memory node. As it is obvious from this memory structure, the effective memory throughput scales with the number of the memory nodes, irrespective of the view point and the projection method.

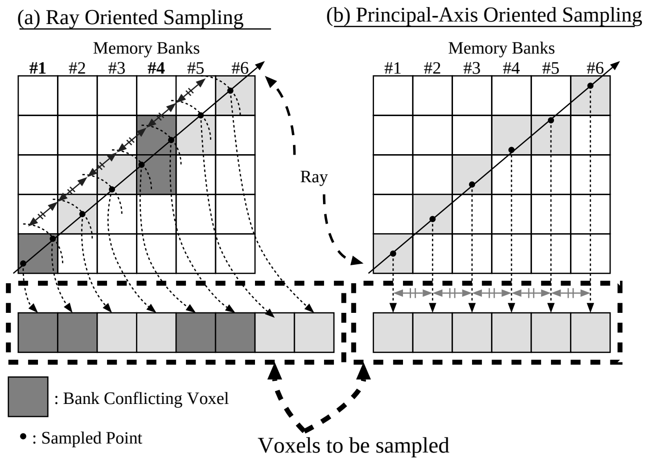

Figure 1: Simplified Sampling Method

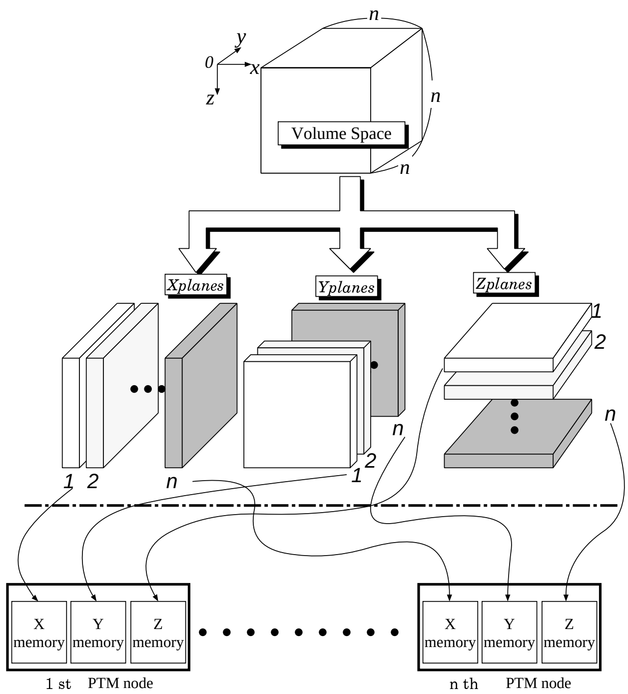

Figure 2: Parallel Treble Volume Memory

*Kyoto University, Kyoto, 606-8501 JAPAN
{moris, syamauti, harase, tomita}@kuis.kyoto-u.ac.jp

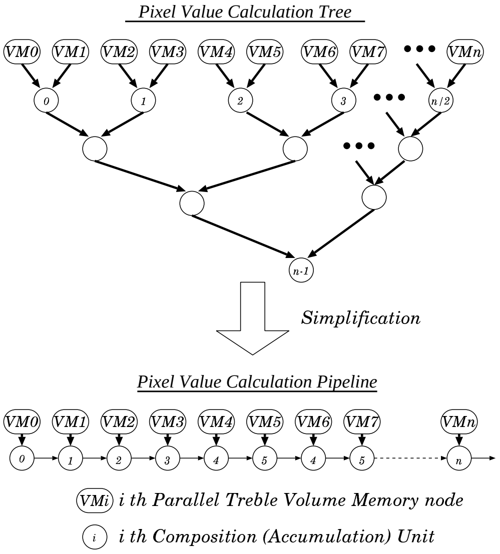

Figure 3: Composition Network

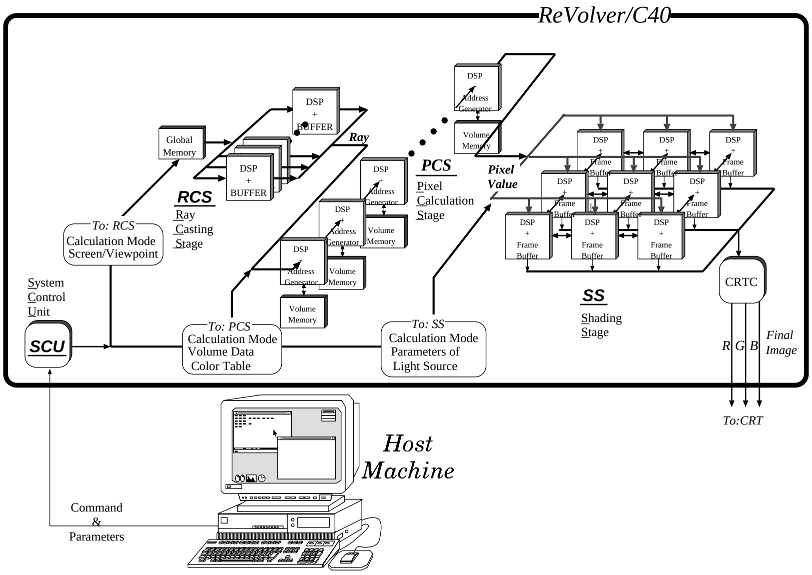

Figure 4: Overview of the Prototype System: ReVolver/C40

2.2 Composition Network

Not like the well-known tree-based composition network[1, 3], we organize the composition network as the link structure(Fig.3). The primary advantages of the link network are the good scalability and the ease of implementation; the cost of wiring becomes half while the logical throughputs of both networks are the same at the output-end. Though the latency increase from $logN$ to N, it is negligible if each created images has the order of N^2 pixels.

3 PROTOTYPE IMPLEMENTATION

We have been developing a prototype hardware system:ReVolver/C40 (Fig.4 and Fig.5) and a part of the system is currently running. According to the measurement on the current system running at 50MHz, estimated performace has fairly good scalability with respect to the number of the memory nodes and achieves 6frames/s for 256^3 volme on 256×256 screen in perspective projection mode with 256 memory nodes.

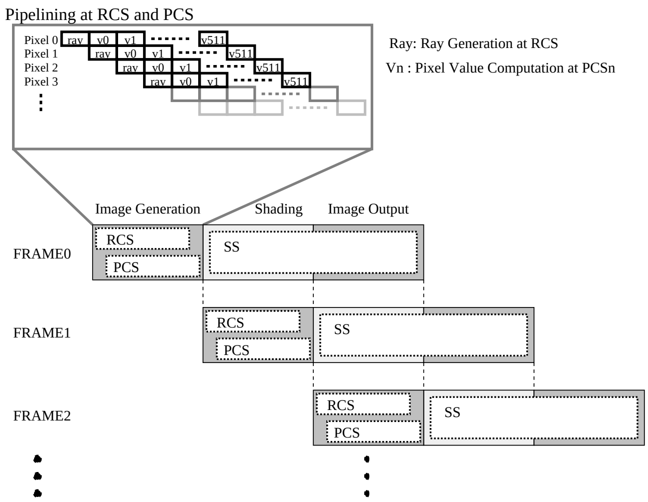

Figure 5: Rendering Pipeline

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