Recent Advances in Volume Rendering

Core-collapse supernova X component of velocity

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Traditional Workflow

What’s wrong with this picture?

wash, rinse, repeat

sim → write → read → analysis/vis → write → read → view

dataset

images

supercomputer vis cluster desktop

Argonne National Laboratory
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Parallel Volume Rendering

Divide and conquer: Input, render, compose, output.
Some Prender Parameters
Knobs to turn, switches to flip, buttons to press

<table>
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<tr>
<th>Argument</th>
<th>Sample Values</th>
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<tbody>
<tr>
<td>DataSize</td>
<td>1120x1120x1120</td>
</tr>
<tr>
<td>ImageSize</td>
<td>1600x1600</td>
</tr>
<tr>
<td>ImageType</td>
<td>ppm, rgb, rgba</td>
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<tr>
<td>IP, port</td>
<td>137.72.15.10, 5000</td>
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<tr>
<td>Stereo</td>
<td>y, n</td>
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<tr>
<td>NumProcs</td>
<td>32768</td>
</tr>
<tr>
<td>NumPipes</td>
<td>16</td>
</tr>
<tr>
<td>NumCompositors</td>
<td>4096</td>
</tr>
<tr>
<td>NumWriters</td>
<td>64</td>
</tr>
<tr>
<td>Variable</td>
<td>pressure, !</td>
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Performance Results

Limiting the number of compositors improves compositing time by up to 30X.

Total and Component Time

- total
- I/O
- render
- old composite
- new composite

Time (s) vs Number of processors
Time Distribution

Reading the data from storage dominates the total cost of a time step.

The effect of raw rendering speed is minimal. Hence, s/w rendering rates are acceptable, compared to h/w rendering. The most critical factor is parallel I/O performance, followed by interconnection performance.
Efficiency
Welcome to the real world.
Multiple Parallel Pipelines

Hide I/O latency by extending concurrency between time steps.

Effect of Processing Time Steps Concurrently

(864^3 data, 1024^2 image)

Frame rate (Hz)

Number of parallel pipelines

512 cores per pipe
1024 cores per pipe
2048 cores per pipe
4096 cores per pipe
8192 cores per pipe
Multiple Writers
Reduce memory footprint, gather time, overall composite and output time.

Memory footprint per core = 70MB + 2.5KB * image size / writing_cores + 4 * volume size / rendering_cores

Eg.,
512 MB - 2 MB OS per core (vn mode):
2048^3 volume, 2048^2 image
-> Need ~128 cores minimum
Multiple Writers Performance

Improve overall output time by selecting the optimal number of writers.

Composite, Gather, Write Times for Varying Numbers of Writers

2048 Renderers, 2048 Compositors, 2048^2 Image

64 writers best for most cases; writers need to be distributed among I/O nodes.
Virtual Reality for Sci Vis

Be the data.

HMD
CAVE
GeoWall

Power Wall
Tiled Display
Autostereo
Generating Stereo Images

By reorganizing parallel pipelines, casting perspective rays, streaming image pairs.

Parallel Perspective Projection Method
Viewing Stereo Images

Applying VR concepts to sci vis: autostereo viewing and natural interactions, from display wall to desktop.
## Recent Advances in Volume Rendering

**Challenges, questions, looking ahead**

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