Data dependent optimizations for permutation volume rendering

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Outline

- Main Contributions
- Related work
- Linear octrees
- Performance
- Quality performance tradeoffs
- Conclusions
Main contributions

- 3 to 5X Speedup using data dependent acceleration
- 39.3 Mvoxels/second absolute fastest result on MasPar
- Quality time tradeoffs developed
Related work, Mvoxels/second (MasPar MP-1 performance)

- Wittenbrink and Somani, Wz, PRS’93
- Hsu, Hz, PRS’93
- Vezina, Vz, Vol. Vis’92
MasPar MP-1 Speedup 16k over 1k processors

- Wz, Supralinear
- Wt, linear
- Vf, Vz, G*, Hz follow

Ideal 16

Best

21.3

15.7

5.8
Background, permutation warping

- Regular Grids
- $M$, one-to-one mapping
- $T^{-1}$ inverse view transform

Diagram:
- Processor Grid
- Object Space
- Screen Space
Assignment is always 1 to 1
Linear octrees (quadtree example)

4 Linear Quadtrees

PE0: 00,01,02,03,10,11,12,13,20,21,22,23,3X

PE3: XX

PE1, PE2: NULL

4 Processors
Static load balancing

Before

PE0

PE1

PE2

PE3

No nodes

After

PE0

PE1

PE2

PE3

Visual Data Exploration and Analysis V
Octree pseudo-code

- Create, condense, and load balance octrees
- Sort nodes by octree level
- while(local nodes) {
  - pick $U, U' = MU, p = T^{-1} U'$
  - value = interpolateOctree($p$)
  - for all 3D voxels in $U_i$ {
    - $U'_j = MU_i$ // permutation assignment
    - send(value, $U'_j$)"
}
Performance achieved
MP2 NASA Goddard

Octree
Hsu
Baseline

Mvoxels/second

8
7.5
7

WzO
WtO
Hz
Wz
Wt

39
37

4096
16384
### Error versus threshold

<table>
<thead>
<tr>
<th>Time (milliseconds)</th>
<th>Threshold</th>
<th>RMS Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1867</td>
<td>0</td>
<td>0.87</td>
</tr>
<tr>
<td>1751</td>
<td>1</td>
<td>0.92</td>
</tr>
<tr>
<td>804</td>
<td>5</td>
<td>2.7</td>
</tr>
<tr>
<td>710</td>
<td>10</td>
<td>3.0</td>
</tr>
<tr>
<td>456</td>
<td>50</td>
<td>7.2</td>
</tr>
</tbody>
</table>

Visual Data Exploration and Analysis V
Error versus Run time

High Quality

RMS Error

Runtime

Error

Fast

Milliseconds

Visual Data Exploration and Analysis V
Speedups of 16k over 4k MP-2
Ideal is 4.0 (128³ volume)

<table>
<thead>
<tr>
<th>Method</th>
<th>Speedup</th>
</tr>
</thead>
<tbody>
<tr>
<td>Octree</td>
<td>3.6</td>
</tr>
<tr>
<td>Baseline tril</td>
<td>3.85</td>
</tr>
<tr>
<td>Baseline zoh</td>
<td>4.05</td>
</tr>
</tbody>
</table>
Conclusions

- 3-5X Improvement over baseline
- 39.3 Mvoxels/second fastest MasPar renderer
- One of the highest fidelity (trilinear/higher possible)
- Possibly superior to shear warp for massive parallelism
- Linear octrees effective on SIMD