Octreemizer: A Hierarchical Approach for Interactive Roaming Through Very Large Volumes

John Plate
Michael Tirtasana, Rhadamés Carmona, Bernd Fröhlich
john.plate@imk.fraunhofer.de

Virtual Environments Research
Fraunhofer IMK
Sankt Augustin
Germany
Geo-Scientific Exploration in Virtual Environments

- Interactive frame rates
- Massive amounts of data
  - Multi gigabyte seismic volumes
  - High resolution interpreted data
  - Multi-attribute well log data
  - Reservoir data
  - ...
- Well editing
- Distributed work
Reflection Seismic

Octreemizer
Large Volumes: Overview and Roaming

Octreemizer

Fraunhofer Institut Medienkommunikation
Multi-Resolution Representation
Octreemizer™

- **Hierarchical bricking**
  - Octree
  - Adaptive display

- **Constraints**
  - Interactive frame rates
  - Bricks fit in texture & main memory
  - 3D Texture reload limit per frame

- **Paging**
  - From hard disk to main memory
  - From main memory to texture memory

- **Sampling geometry**
  - Arbitrary polygonal meshes
3D-Texture Paging Algorithm

Viewer

Insert slice hierarchically until max texture memory is used (e.g. 9 bricks)
3D-Texture Paging Algorithm

Collapse blocks until reload limit is reached (e.g. 4 bricks, green)
Hierarchical Predictive Volume Paging - Geometry Extrapolation

- Combination of current and predicted wish list

Octreemizer
Hierarchical Predictive Volume Paging – Moving Hull

- Neighbors of most recent used bricks loaded first
- Bricks loaded asynchronously from hard disk
- Octree file format optimized for speed
  - Single file, precalculated file offsets
  - Child bricks stored sequentially
- Start up time reduced to minimum

Octreemizer
Performance measurements

<table>
<thead>
<tr>
<th></th>
<th>120 MB</th>
<th>2.1GB</th>
<th>16GB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data set size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Texture memory size</td>
<td>10 MB</td>
<td>64MB</td>
<td>64MB</td>
</tr>
<tr>
<td>Main memory cache</td>
<td>120 MB</td>
<td>400MB</td>
<td>400MB</td>
</tr>
<tr>
<td>Time per frame static</td>
<td>7ms</td>
<td>15ms</td>
<td>14ms</td>
</tr>
<tr>
<td>Time per frame moving</td>
<td>48ms</td>
<td>45ms</td>
<td>46ms</td>
</tr>
</tbody>
</table>

- Performance for static volume lens dominated by texture fill rate
- Performance for moving volume lens dominated by texture reload and geometry insertion
- No cache misses produced by loading bricks from hard disk
### Influence of Prediction Strategy

<table>
<thead>
<tr>
<th></th>
<th>min</th>
<th>max</th>
<th>average</th>
<th>dev</th>
</tr>
</thead>
<tbody>
<tr>
<td>slow / no P</td>
<td>3.6</td>
<td>5.0</td>
<td>4.85</td>
<td>0.18</td>
</tr>
<tr>
<td>slow / P</td>
<td>4.6</td>
<td>5.0</td>
<td>4.99</td>
<td>0.017</td>
</tr>
<tr>
<td>fast / no P</td>
<td>3.2</td>
<td>4.5</td>
<td>4.18</td>
<td>0.15</td>
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<tr>
<td>fast / P</td>
<td>4.1</td>
<td>4.4</td>
<td>4.22</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- [ ] Less frames without texture reload
- [ ] Average brick depth higher or equal
- [ ] Standard deviation much smaller
- [ ] Better visual quality

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Octreemizer
3D Texture Fill Rates

Fill (Megapixel / sec)

Triangle Size (Pixel)

- SGI Onyx2 IR2
- ATI FireGL4
- nVidia GeForce3

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3D Texture Fill Rates

Size of volume bricks (Kilobyte)

Fill (Megapixel / sec)

- SGI Onyx2 IR2
- ATI FireGL4
- nVidia GeForce3
3D Texture Download

<table>
<thead>
<tr>
<th>Bricksize (Kilobyte)</th>
<th>Reload (Megabytes/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>50.0</td>
</tr>
<tr>
<td>8</td>
<td>100.0</td>
</tr>
<tr>
<td>16</td>
<td>150.0</td>
</tr>
<tr>
<td>32</td>
<td>200.0</td>
</tr>
<tr>
<td>64</td>
<td>250.0</td>
</tr>
<tr>
<td>128</td>
<td>300.0</td>
</tr>
<tr>
<td>256</td>
<td>350.0</td>
</tr>
</tbody>
</table>

- **SGI Onyx2 IR2**
- **SGI Onyx2 IR2 (Interleaved)**
- **ATI FireGL4**
- **ATI FireGL4 (Interleaved)**
- **nVidia GeForce3**
Current and Future Work

- 3D filters: contrast enhancement, erasing, iso-surfaces, gradient shading, modeling, ...
- Volume shading, advanced lookup table applications
- 4D data, multi-attribute volumes, adaptive representation of FEM data