New Perspectives for Large Data Visualization Research

Kwan-Liu Ma
Department of Computer Science
University of California at Davis
Topics

• In Situ Data Processing and Visualization
• Scientific Storytelling
Large Data Visualization

Supercomputer → Storage → Visualization Machine

See your data anytime?
Large Data Visualization

Supercomputer → Storage → Visualization Machine
Visualization by Proxy aka Explorable Images

- A compact, intermediate representation of the data of interest
- Visualization by proxy for deferred interaction
- Explorable in
  - Spatial domain
  - TF space
  - Temporal domain
  - Rendering space
An explorable image is larger than a regular image, but much smaller than the raw data and a typical video.
Computational Cost

![Graph showing computational cost for different methods: 3D ambient occlusion (4), Proxy-based ambient occlusion (5), 3D volume rendering (1), Multiperspective compositing (3), Proxy-based compositing (2). The graph plots relative time against volume size.](image)
Visualization by Proxy

<table>
<thead>
<tr>
<th>Number of processors</th>
<th>240</th>
<th>1920</th>
<th>6480</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulation time (sec)</td>
<td>8.7204</td>
<td>9.3393</td>
<td>9.5573</td>
</tr>
<tr>
<td>I/O time (sec)</td>
<td>9.4563</td>
<td>26.051</td>
<td>52.565</td>
</tr>
<tr>
<td>Total volume rendering time (sec)</td>
<td>0.3817</td>
<td>0.6155</td>
<td>0.7359</td>
</tr>
<tr>
<td>Boundary voxel exchange</td>
<td>0.0042</td>
<td>0.0059</td>
<td>0.0064</td>
</tr>
<tr>
<td>Ray casting</td>
<td>0.0226</td>
<td>0.0148</td>
<td>0.0095</td>
</tr>
<tr>
<td>Image compositing</td>
<td>0.3549</td>
<td>0.5948</td>
<td>0.7200</td>
</tr>
<tr>
<td>Total IAF computation time (sec)</td>
<td>1.2775</td>
<td>1.3938</td>
<td>1.3973</td>
</tr>
<tr>
<td>Boundary voxel exchange</td>
<td>0.0026</td>
<td>0.0066</td>
<td>0.0068</td>
</tr>
<tr>
<td>IAF construction</td>
<td>0.0806</td>
<td>0.0729</td>
<td>0.0450</td>
</tr>
<tr>
<td>IAF compositing</td>
<td>1.1943</td>
<td>1.3143</td>
<td>1.3455</td>
</tr>
</tbody>
</table>
Particle Path Visualization by Proxy
Visualization by Proxy

• A viable solution for interactive visualization of large, complex data
• In-situ generation of explorable images as a remedy to data reduction, a previewing solution, or a solution to make visualization that is impossible/impractical to make after the simulation
• Data visualization on mobile devices or via a web browser
• An idea generalizable for different types of visualization
In Situ Data Reduction

- Lossless compression for floating-point data
- Importance based visualization and data reduction
- Other feature extraction and tracking methods

Small eddies are hidden in the multi-layer flow
Distance Field Computing

- Distance fields can be used as importance fields to guide rendering, data compression, sampling, and feature-based optimizations.
- Scalable distance field calculations have been achieved.
- Tests on the parallel implementation show the data that must be exchanged is under 0.01% of the total data, and the cost to exchange the data is under 0.2% of the overall time.
Support for Scientific Storytelling

- High performance and high quality rendering
Support for Scientific Storytelling

- High performance and high quality rendering
Support for Scientific Storytelling

- High performance and high quality rendering
Support for Scientific Storytelling

- Visualization interfaces
Support for Scientific Storytelling

• Visualization interfaces
Support for Scientific Storytelling

- Visualization interfaces
Support for Scientific Storytelling

• Animation support
Support for Scientific Storytelling

- Animation support
Support for Scientific Storytelling

- Video narratives