Scalable Data Servers for Large Multivariate Volume Visualization

Presented by

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Motivation

- Volumetric multivariate time-varying datasets are often complex and massive in size.
- Efficient and interactive selection and visualization of subsets is not easily done, as datasets will not fit in core.
- Real-world example: astrophysics simulation of supernova generates 300 time steps of a spatial resolution of 864x864x864 with multiple attributes stored at each voxel.
- Few systems can adequately support (interactive) visualization of such enormous datasets.
Our approach: Overview

Parallel data management and effective data culling
Data culling

- Parallel data culling on the granularity of individual voxels.
- Process is driven by compound boolean range queries.
- Cull unnecessary voxels as early in the visualization pipeline as possible, i.e., on the server side.
Parallel data management

• The entire dataset is distributed among a number of networked independent computers according to space filling curve order in the high-dimensional attribute space.

• Load-balancing can be achieved among data servers, independent of the range queries.
Parallel data management

- Each data server leverages a very compact data structure similar to B-tree to maintain all voxels distributed to it.
- Queries to a server can be responded to quickly with a query rate of 4.2 million relevant voxels per second across a local area network.
Requirements

• System of networked workstations without any special hardware or software.

• All data servers combined need to hold the entire dataset in main memory in a compressed form.

• Queries will need to fit into client’s main memory to render.

• If requirements cannot be met, the system will still be operational, but performance will be hampered.
Results—Datasets

**TSI**—Time-varying (6 time steps),
Multivariate (11 attributes),
864x864x864
105 GB of raw data

**RMI**—Time-varying (3 time steps),
Multivariate (11 attributes),
1024x1024x960
82 GB of raw data

Tests run with 20, 30, and 40 servers
Results

Querying Rates

million relevant voxels per second

million relevant voxels per query

- TSI-20
- TSI-30
- TSI-40
- RMI-40
Results

• Network seems to be the bottleneck of the system:
  – Even with a Quadrics Elan3 network (single-direction bandwidth of 400 MB per second).

• We can query at 144 MB/s or about 9 million voxels per second in parallel.

• The load imbalance among servers ranged between a mere 0.012% to 0.155% for medium and large queries.
Integration into VisIt

Scalable data servers have been integrated into the free interactive parallel visualization and graphical analysis tool VisIt as a module in version 1.7.

http://www.llnl.gov/visit
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