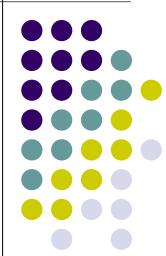
Large Scale Time-Varying Data Visualization

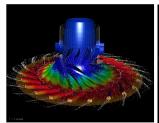


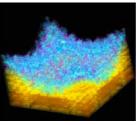
Han-Wei Shen

Department of Computer and Information Science

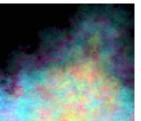
The Ohio State University

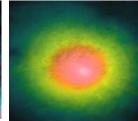










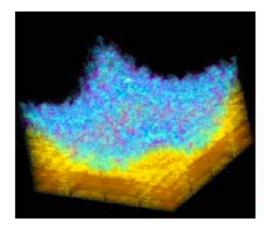


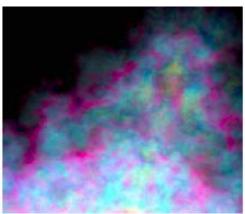
Applications

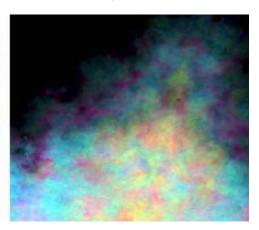
- Large Scale Time-Dependent Simulations
- Richtmyer-Meshkov Turbulent Simulation (LLNL)
 - 2048x2048x1920 grid per time step (7.7 GB)
 - Run 27,000 time steps
 - Multi-terabytes output



LLNL IBM ASCI system



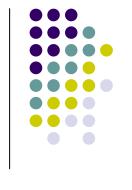


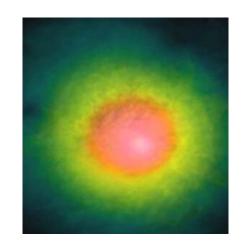




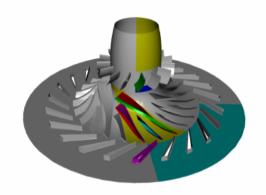
Applications

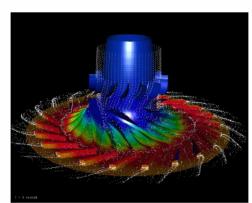
- Oak Ridge Terascale Supernova Initiative (TSI)
 - 640x640x640 floats
 - > 1000 time steps
 - Total size > 1 TB
- NASA's turbo pump simulation
 - Multi-zones
 - Moving meshes
 - 300+ time steps
 - Total size > 100GB





ORNL TSI data

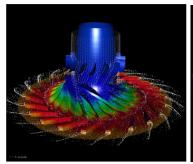


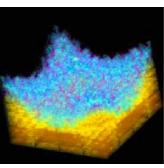


NASA turbo pump



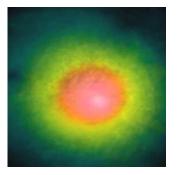
- Interactive data exploration
 - Quick overview, detail on demand
- Feature enhancement and tracking
 - Display the "invisible"
 - Understand the evolution of salient features over time
- Challenges
 - managing, indexing, and processing of data











Research Focuses

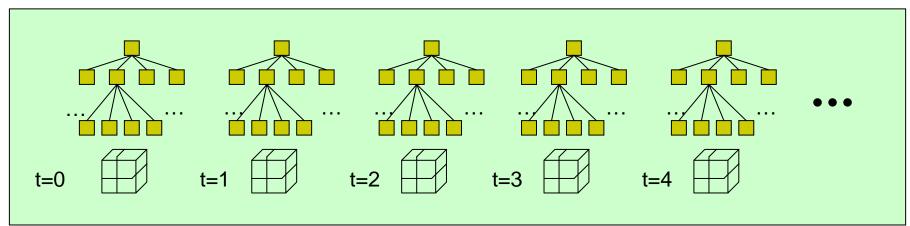


- Multi-resolution data management schemes
- Acceleration Techniques
 - Efficient data indexing
 - Coherence exploitation
 - Effective data culling
 - Parallel and distributed processing
- Feature tracking and enhancement
 - Visual representation
 - Geometric tracking





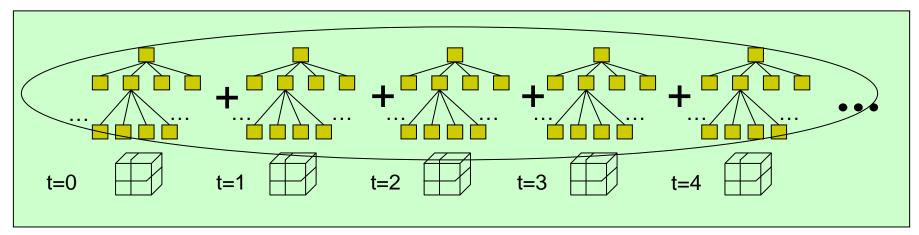
- Goal: allow interactive spatial-temporal data browsing at arbitrary scales
- Based on wavelet transform and Huffman encoding
- Create a multiresolution data hierarchy called wavelet based time-space partitioning tree (WTSP tree)







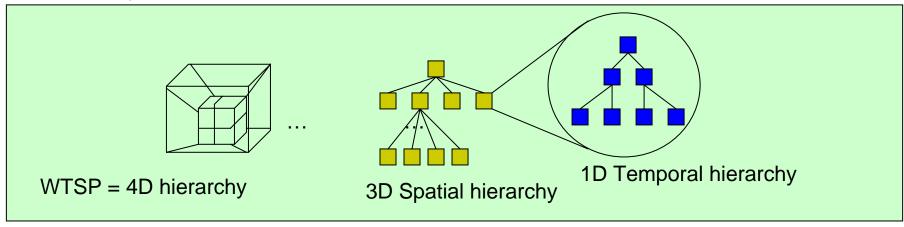
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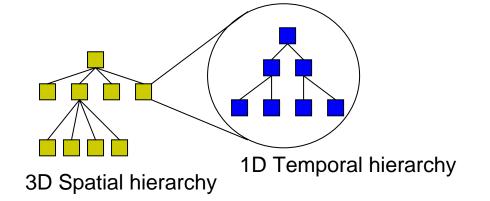


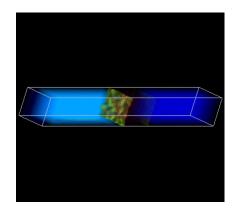
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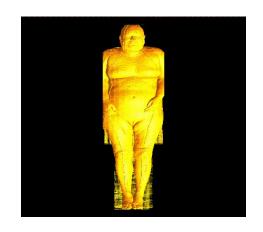


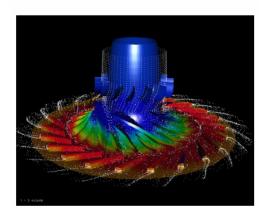
Accelerated Techniques

- Utilize temporal coherence
 - Coherence in image
 - Coherence in visibility
 - Coherence in indices









11.2 speedup, 3.4% image diff.

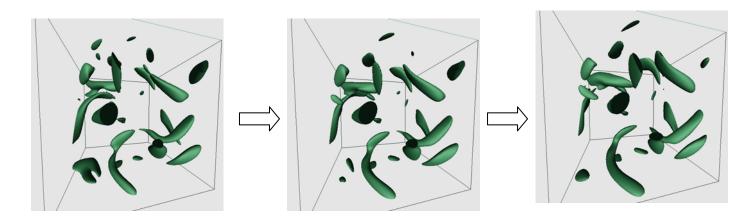
75% invisible blocks removed

80% space saving for indices





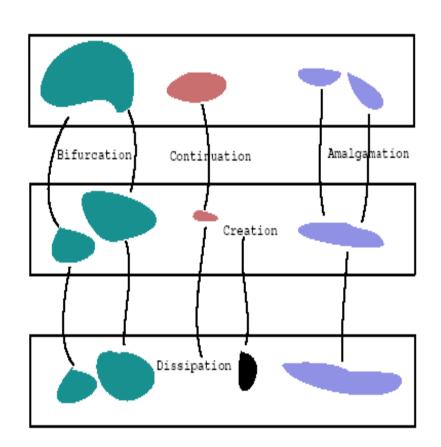
- Two main goals:
 - Identify correspondence



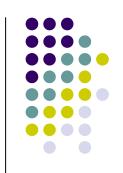
 Detect important evolution events and critical time steps

Strategy 1: Computing 4D Geometry

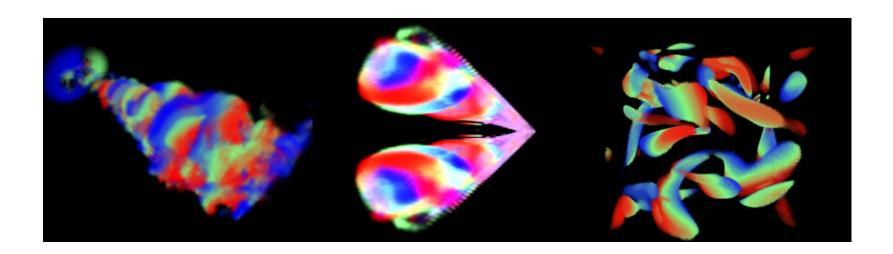
- 3D time-varying = 4D
- Extract "isosurfaces" from 4D hypercubes
- Slice the 4D geometry to get the surface at the desired time step
- Analyze the 4D geometry to discovery important evolution events



Strategy 2: High Dimensional Visualization



• Hyper-Projection to 3D image plane and then use graphics hardware to perform real time rendering



Parallel Computation



- To utilize the parallel computation power, we need to partitioning and distribute the hierarchy
- Effective data management is a must!
 - Eliminate data dependency while minimizing data replication
 - Ensure run time load balancing
 - Efficient streaming and caching of raw or reconstructed data from

the data repository



1D Tempora

3D Spatial hierarchy

1D Temporal hierarchy





- We are now able to efficiently visualize large scale time-varying data generated by DOE scientists
- Most of the algorithms are run on either local workstations or clusters
 - One of the major challenges remained is actually how to move data
- Inter-operability among different algoirthms and software components will be a key for practical uses