Feature-Based Analysis of Large-Scale Data using Limited Resources and Interactive Techniques for Exploration

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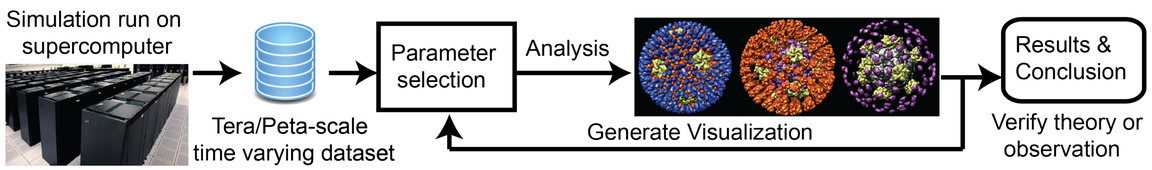


Challenges in Understanding Large-Scale Simulation

Defining, extracting and analyzing features in the increasingly large and complex datasets produced by state of the art simulations still poses a significant challenge. The simulation data sizes and the repetitive parameter selections involved make this even more challenging.

Topology-Based Analysis

We pre-compute a wide range of different feature types and store them in a parameter-independent manner to allow exploration in different parameter choices. In that, we construct a hierarchical merge tree (Figure 2), a highly compact, yet flexible feature representation which allows us to extract a set of feature for any given parameter instantly without any re-computation.

We also create a new flexible, efficient, compact meta-graph (Figure 3) which, similar to the topological encoding for features, stores not one particular tracking graph but instead the entire family of graphs for all possible feature parameters. From this meta-graph we can interactively extract a specific graph for particular parameters and correlation metrics.

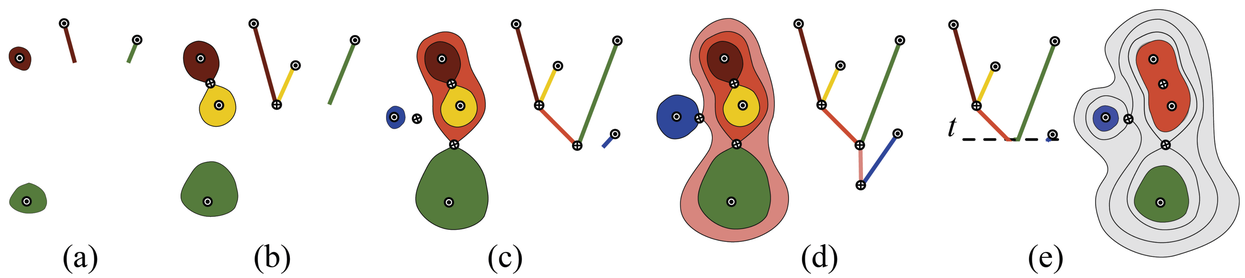


Figure 2: Each contour represents one "arc" on the merge tree. (a-d) shows the construction of a merge tree as the function value is swept top -down. (e) shows how thresholds can be used to extract features from the tree.

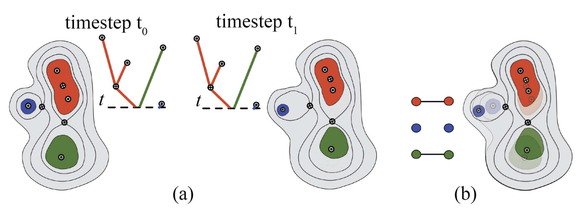
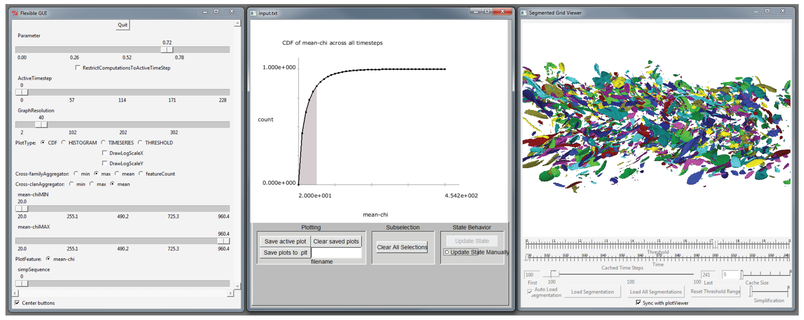


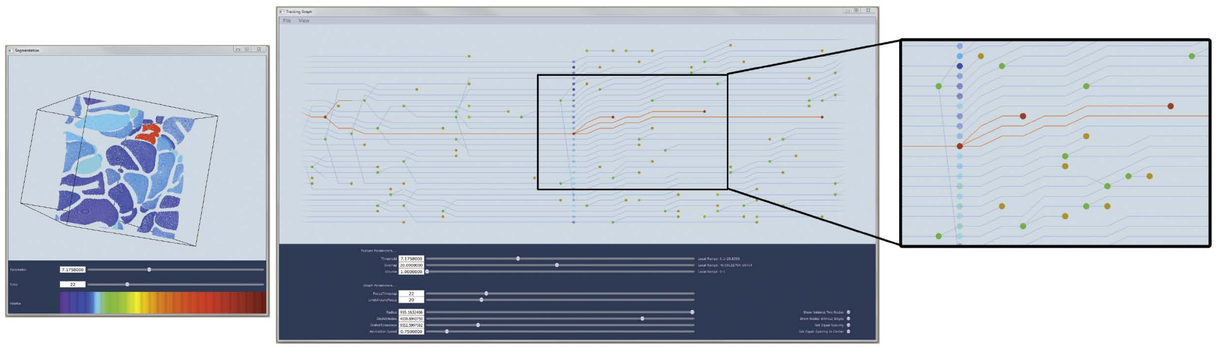
Figure 3: Initial edges of the meta-graph for two time steps.

Framework for Analyzing Features using Aggregate Statistical Techniques



- On-the-fly aggregation of feature-based spatial and temporal statistics
- An efficient encoding method for various multi-resolution hierarchies and statistics using feature-based blocked storage
- Interactive creation of spatial and temporal statistical summaries using a novel volume rendering technique.
- A linked view system of statistics and features with an intuitive user interface.

Framework for Analyzing Features by Tracking Individual Features Over Time



- Define and construct a meta-graph in pre-processing from a sequence of feature families
- A progressive algorithm to extract, filter, and simplify a tracking graph from a meta-graph
- A progressive two-stage layout algorithm for tracking graphs
- An interactive linked view system combining tracking graphs and feature displays.

- *Interactive Exploration of Large-Scale Time-Varying Data using Dynamic Tracking Graphs, W. Widanagamaachchi, C. Christensen, P.-T. Bremer and V. Pascucci*
- *Feature-Based Statistical Analysis of Combustion Simulation Data, J. Bennett, V. Krishnamoorthy, S. Liu, R. Grout, J. Chen, P.-T. Bremer and V. Pascucci*
- *Topological Feature Extraction for Comparison of Terascale Combustion Simulation Data, A. Mascarenhas, R. W. Grout, P.-T. Bremer, E. R. Hawkes, V. Pascucci and J. H. Chen*
- *Interactive Exploration and Analysis of Large-Scale Simulations using Topology-Based Data Segmentation, P.-T. Bremer, G. H. Weber, J. Tierny, V. Pascucci, M. S. Day, and J. B. Bell*
- *Analyzing and Tracking Burning Structures in Lean Premixed Hydrogen Flames, P.-T. Bremer, G. H. Weber, V. Pascucci, M. S. Day, and J. B. Bell*
- *Turbulence Effects on Cellular Burning Structures in Lean Premixed Hydrogen Flames, M. Day, J. Bell, P.-T. Bremer, V. Pascucci, V. Beckner and M. Lijewski*

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