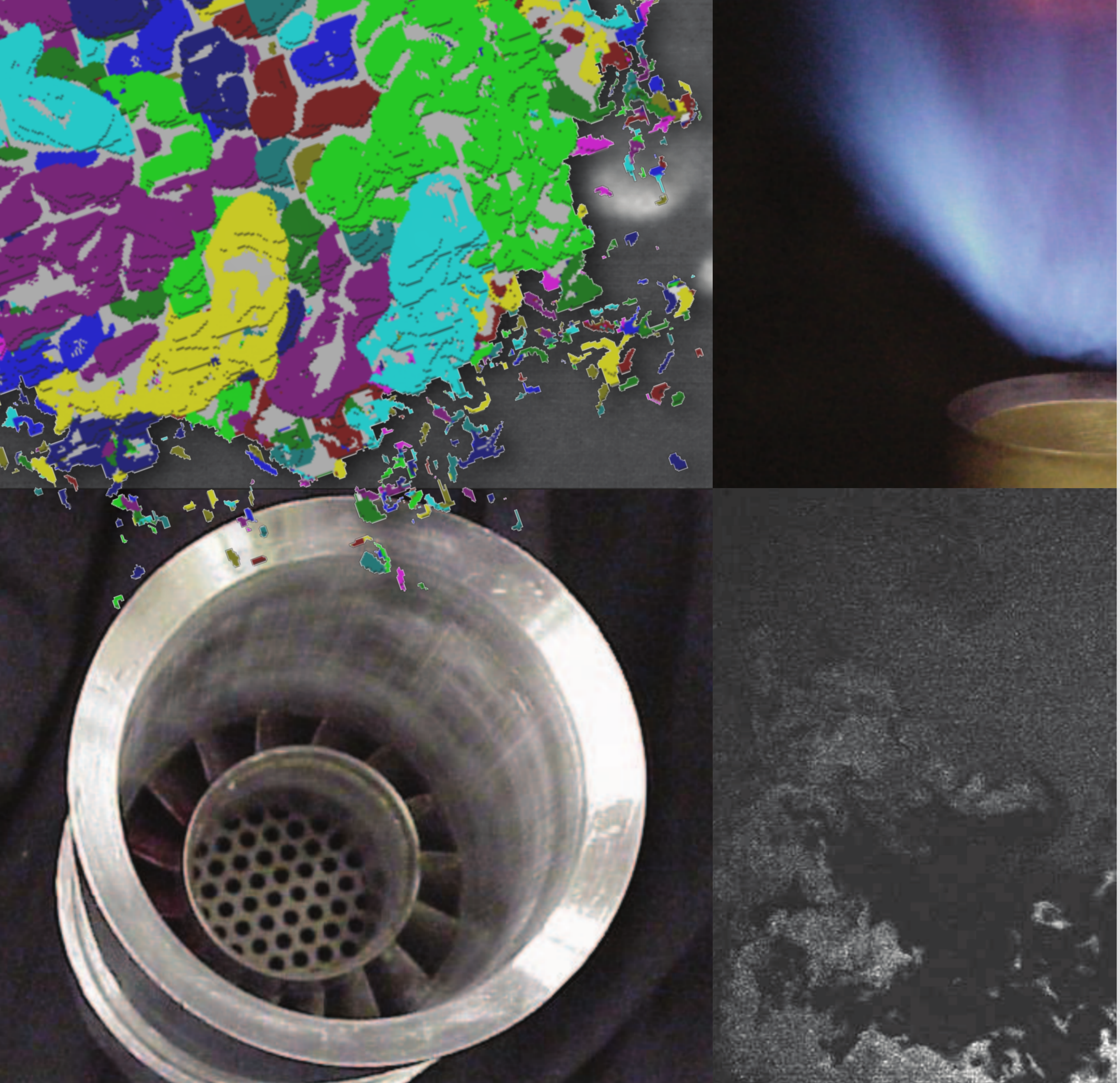

Interactive Exploration and Analysis of Large Scale Simulations Using Topology-based Data Segmentation

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Large-scale simulations are increasingly being used to study complex scientific and engineering phenomena. As a result, advanced visualization and data analysis are also becoming an integral part of the scientific process. Often, a key step in extracting insight from these large simulations involves the definition, extraction, and evaluation of features in the space and time coordinates of the solution. However, in many applications these features involve a range of parameters and decisions that will affect the quality and direction of the analysis. Examples include particular level sets of a specific scalar field, or local inequalities between derived quantities. A critical step in the analysis is to understand how these arbitrary parameters/decisions impact the statistical properties of the features, since such a characterization will help to evaluate the conclusions of the analysis as a whole.

We present a new topological framework that in a single pass extracts and encodes entire families of possible features definitions as well as their statistical properties. For each time step we construct a hierarchical merge tree -- a highly compact, yet flexible feature representation. While this data structure is more than two orders of magnitude smaller than the raw simulation data it allows us to extract a set of feature for any given parameter selection in a post-processing step. Furthermore, we augment the trees with additional attributes making it possible to gather a large number of useful global, local, as well as conditional statistic that would otherwise be extremely difficult to compile. We also use this representation to create tracking graphs that describe the temporal evolution of the features over time. Our system provides a linked-view interface to explore the time-evolution of the graph interactively alongside the segmentation, thus making it possible to perform extensive data analysis in a very efficient manner. We demonstrate our framework by extracting and analyzing burning cells from a large-scale turbulent combustion simulation. In particular, we show how the statistic alanalysis enabled by our techniques provides new insight into the combustion process.

Paper