Interactive Visualization and Exploration of Tracking Graphs for Understanding Evolution of Features

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One of the most common analysis tasks is the need to understand the evolution of time-varying features. Often, there exists some notion of a feature-of-interest at each moment in time, e.g. burning cells in combustion data, twitter topics in social media data, and these features evolve over time. Exploring and analyzing the behaviors of these features with respect to changes in parameters, such as thresholds, and in time is of significant interest.

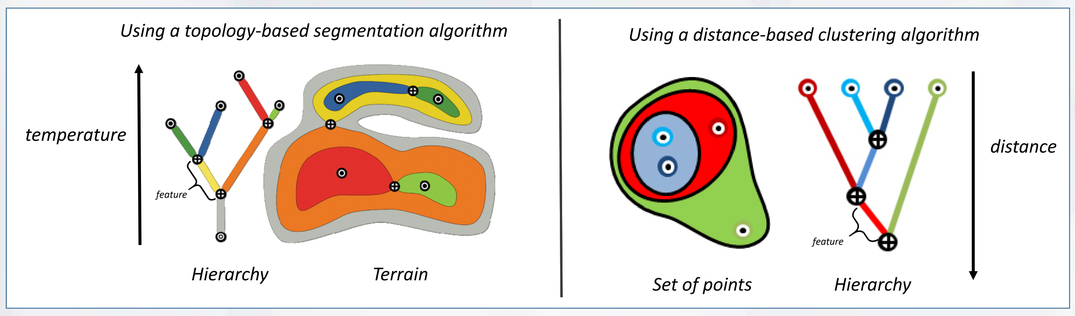
Defining & Extracting Tracking Graphs

Features within a time step are stored using a ***nested feature hierarchy***, which encodes the grouping hierarchy of features for a range of parameter values. Here, users are allowed to define features and their method of grouping according to the underlying data type.

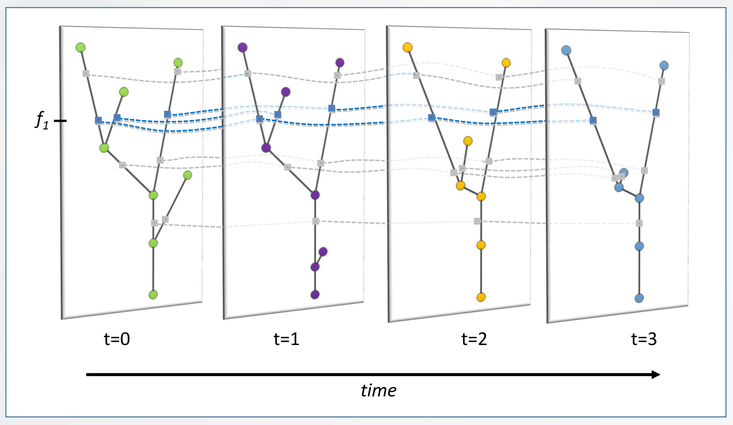
Feature correlations are stored using a new flexible, efficient and compact structure called a ***meta-graph*** which stores the entire family of tracking graphs for all possible feature parameters. Again, users are allowed to specify the feature correlation metric according to the data type.

Given a meta-graph and the corresponding feature hierarchies one can easily extract a tracking graph for a particular parameter setting. For a parameter f1, we first query the feature hierarchies for all features alive at this threshold value and then extract all edges between two living features using the meta-graph.

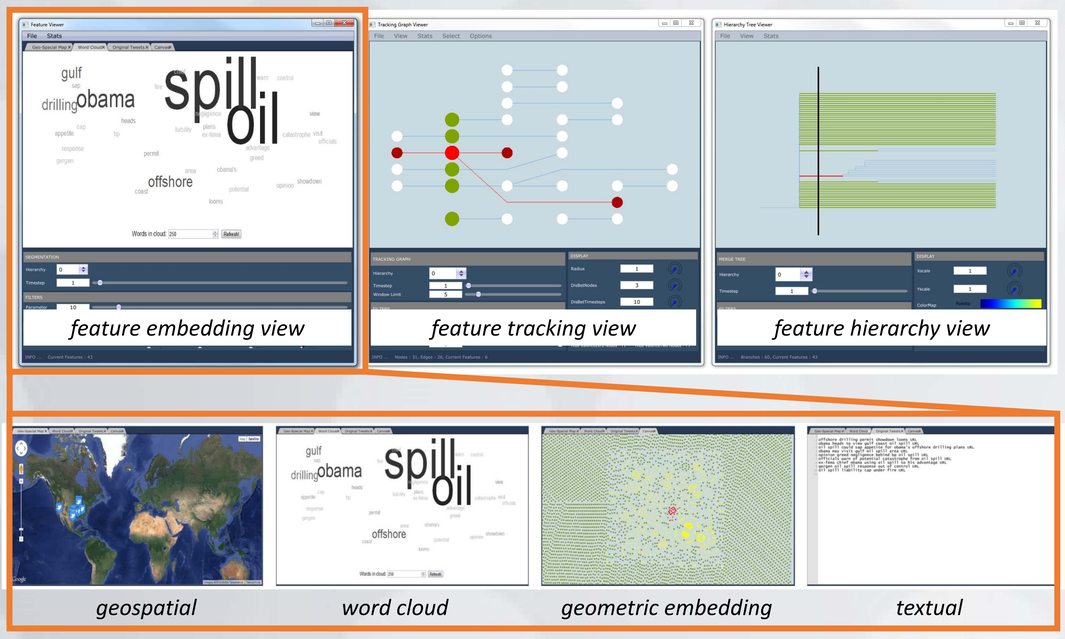
Nested feature hierarchies



Tracking graph extraction



Our framework for analyzing time-varying features



Tracking Graph Visualization

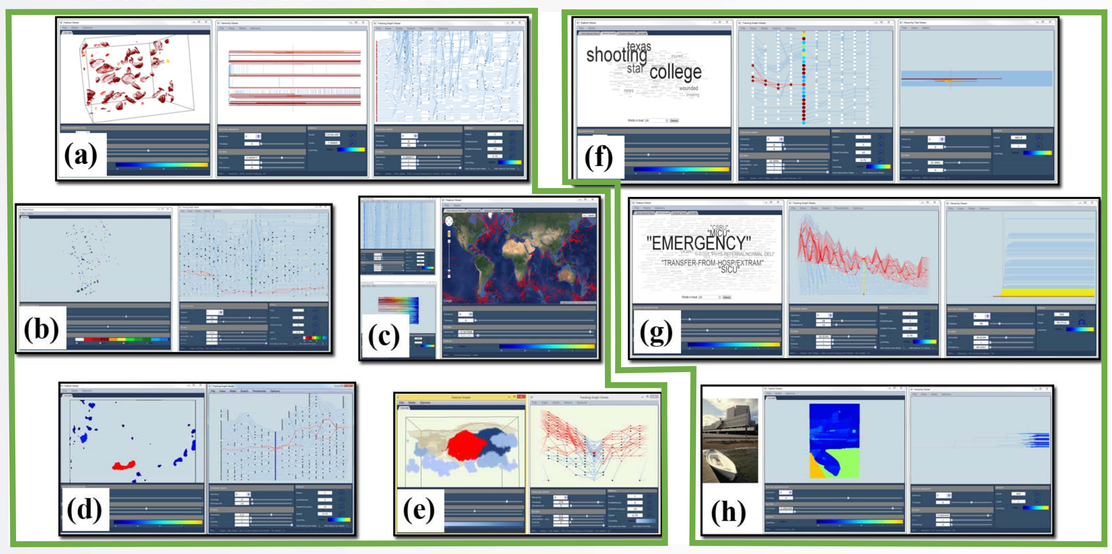
We always process the tracking graphs with respect to a focus time step and a window of interest. This limits our focus of interest to a certain sub-region of the global tracking graph and the user is able to interactively change time steps, expand and contract the window of interest and thus explore the entire graph.

In addition to employing progressive graph layout & visualization (i.e. fast initial graph layout and a slow greedy layout), we also provide various options to reduce the visual complexity of tracking graphs (i.e. graph sub-selection and localized threshold-based methods).

Framework Generality

	Data set	Feature Hierarchy	Feature Correlation
(a)	Combustion	Using topology-based segmentation the hierarchy of burning cells for a range of fuel consumption rates	Feature intersection-based (region overlap), Distance based
(b)	Cosmology	Using distance-based clustering the hierarchy of halos for a range of distance (linking length) values	Feature intersection-based (region overlap)
(c)	Ocean science	Using topology-based segmentation the hierarchy of ocean eddies for a range of Okubo-Weiss values	Feature intersection-based (region overlap)
(d)	Weather	Using topology-based segmentation the hierarchy of storm systems for a range of temperature values	Distance-based
(e)	Plasma-surface Interactions	Using distance-based clustering the hierarchy of helium bubbles for a range of distance values	Feature intersection-based (region overlap)
(f)	Social Media	Using similarity-based clustering the hierarchy of tweets for a range of textual similarity values	Feature intersection-based (element overlap)
(g)	Healthcare	Using similarity-based clustering the hierarchy of patient admissions for a range of patient similarity values	Feature intersection-based (element overlap)
(h)	Image	Using topology-based segmentation the hierarchy of image regions for a range of region saliency values	Feature intersection-based (region overlap)

Scientific data sets ***Non-scientific data sets***



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