Interactive Exploration of Large Tractography and EEG Data for Source Localization

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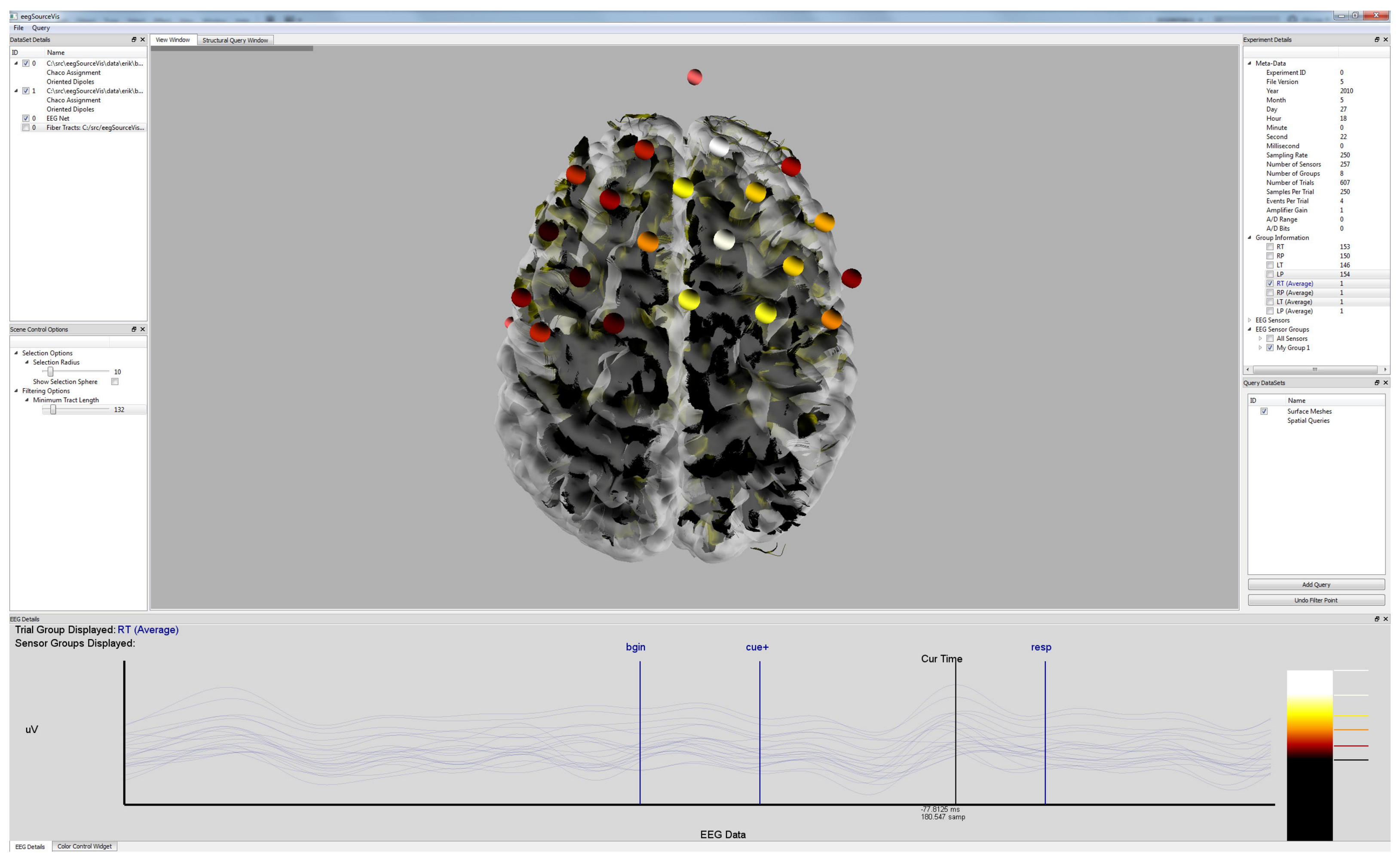
Abstract

Source localization is used to determine which regions of the brain are responsible for generating signals measured by electroencephalography (EEG) sensors on the scalp surface. However, the models and computations required to solve this problem are becoming more complicated as they take advantage of more information during their creation. In this work, we enable the exploration of each data modality involved in the process, both separately and jointly, to ensure their proper integration into the modelling environment.

Each source localization dataset is composed of spatially located time series data (EEG), volumetric images (MRI, DWMRI), and their data products. Using advanced visualization techniques, our system presents the various data in a unified, interactive environment.



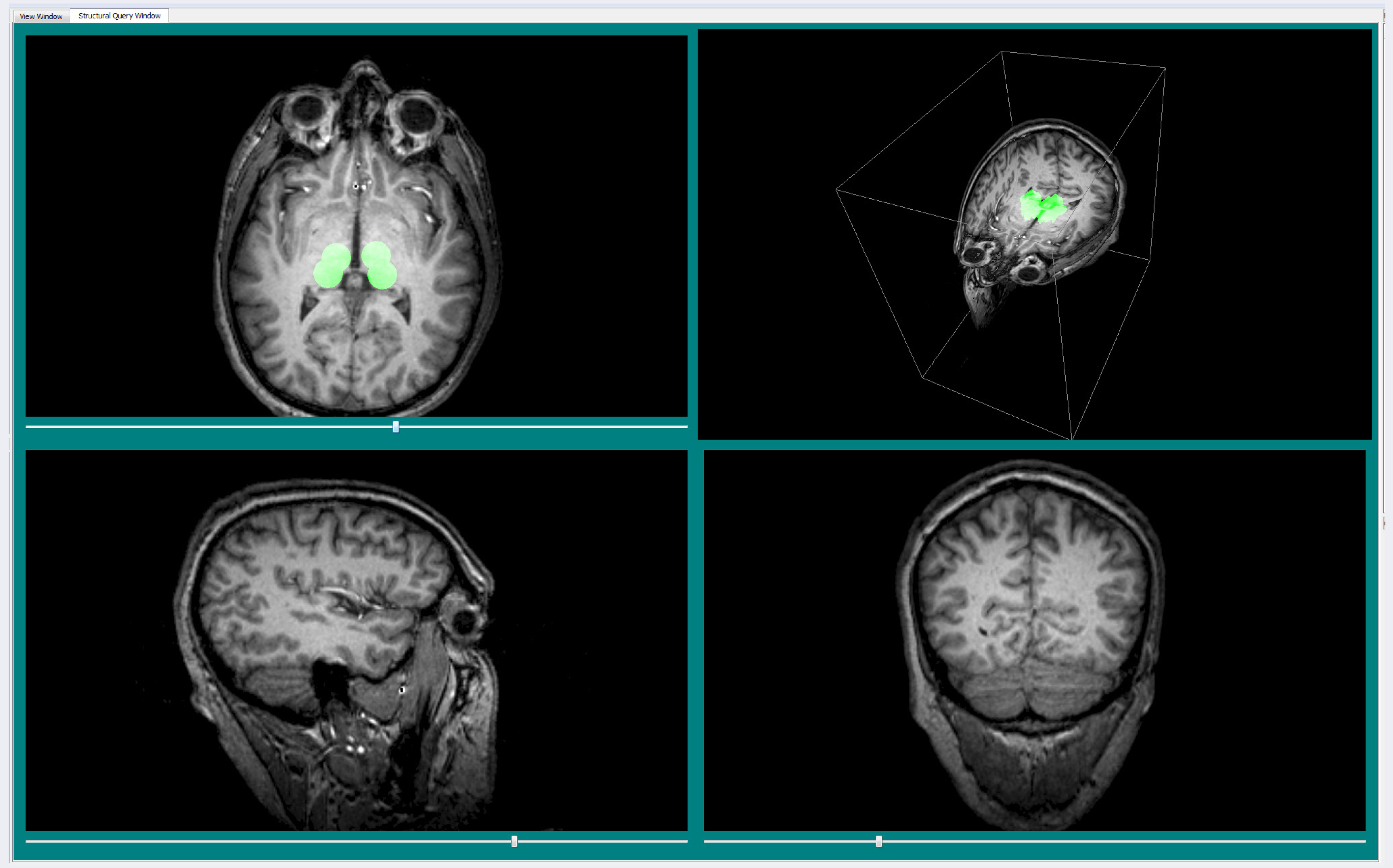
Our system is capable of displaying over 300 MB of EEG data alongside surface data from structural MRI scans in conjunction with over 700 GB of white matter tractography data derived from diffusion weighted imaging (DW-MRI).

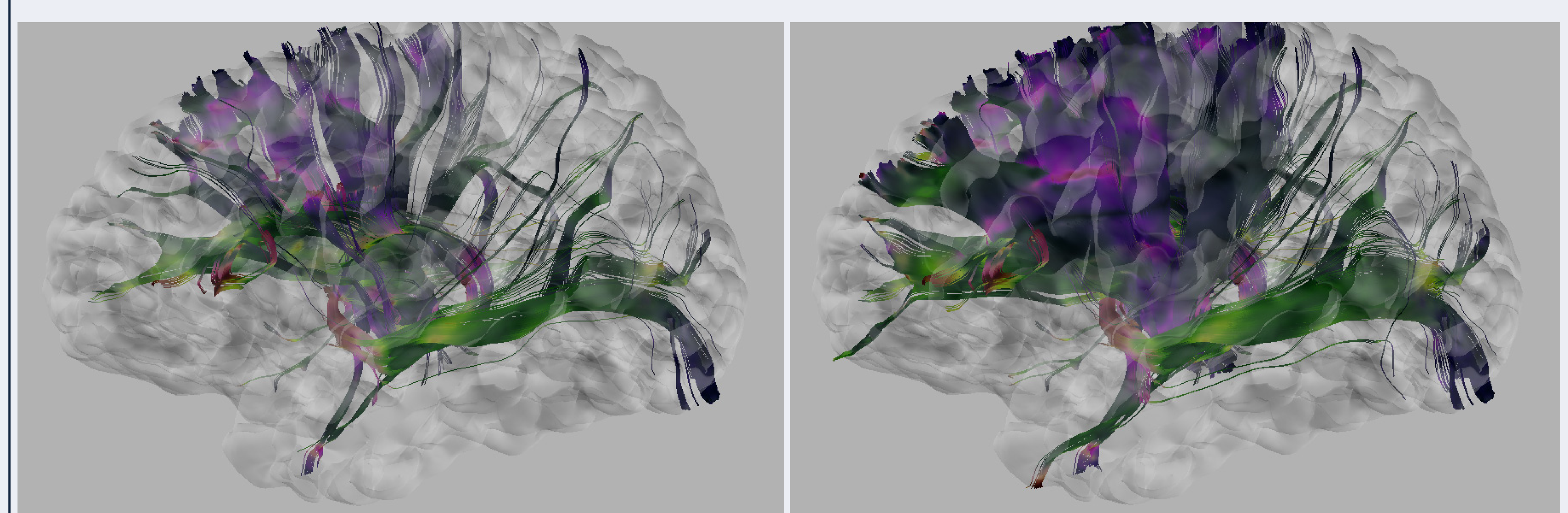
Interactive Rendering:

The need for interactivity and a desire to explore the various data used for source localization reinforces the use of adaptive techniques to adequately render images. To improve the interactive characteristics of our system, we employ a wide range of techniques designed to address the challenges of interactively rendering large datasets. In addition to our multi-threaded streaming approach to rendering tractography, we provide a number of ways to filter this data before rendering. First, tracts are filtered by their length to reduce visual clutter associated with poorly placed tractography seeds; however, this may also be used to reinforce queries designed to extract fibers connecting distant regions of the brain. Second, users may query tractography data to explore connected regions of the cortex. Finally, structural filtering is performed by using structural MRI data to define regions that white matter tracts must

Filtering Tractography Data:

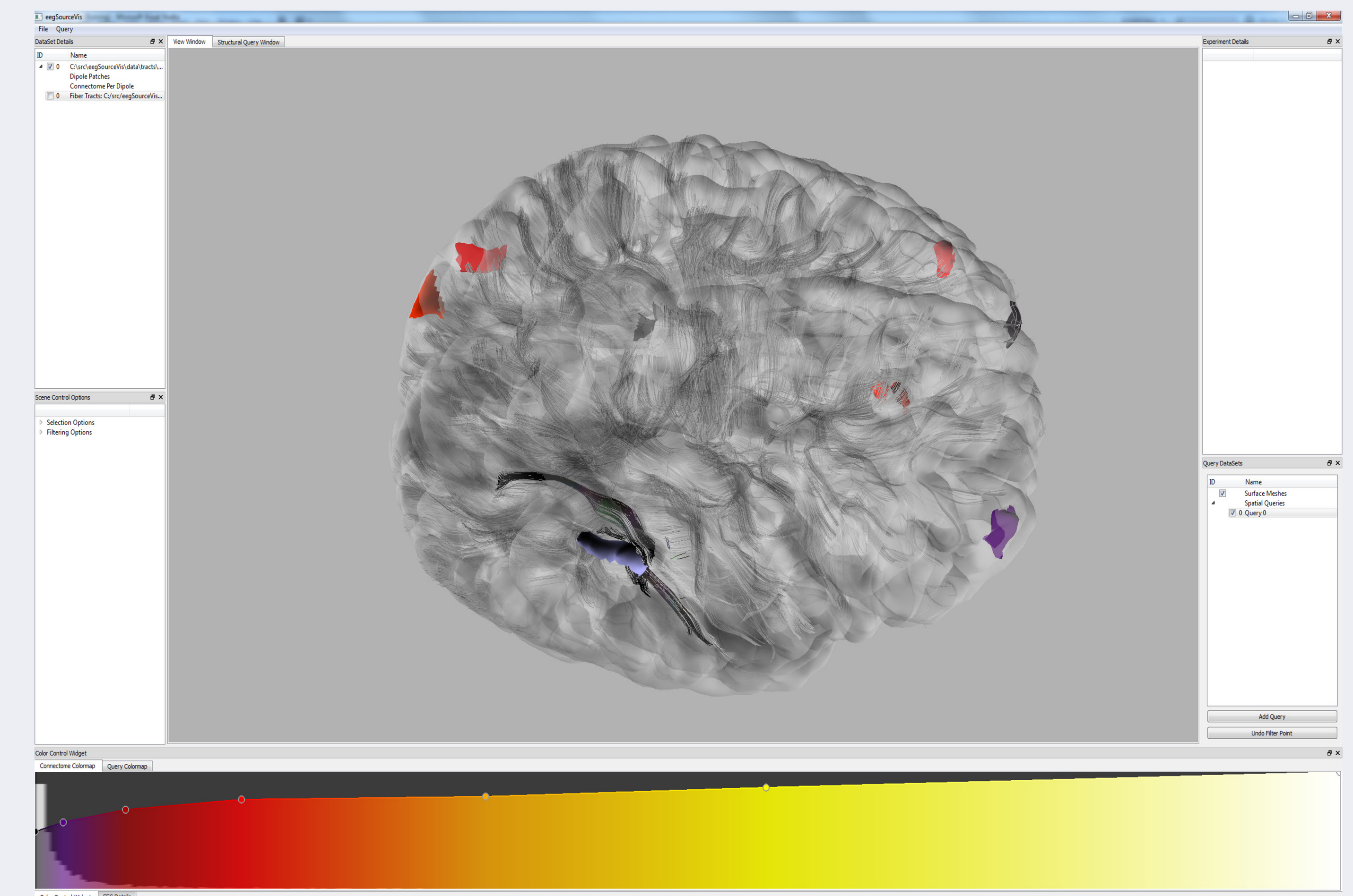
Filtering of large tractography datasets is performed by multi-modal structural queries. Here, The thalamus is highlighted in a structural MRI. The thalamus acts as a switchboard in the brain, connecting and coordinating different functional regions. Due to the large size of tractography data (approx. 750 GB), we rely on a streaming approach to progressively rendering the white matter tracts found in DW-MRI. On the left is a rendering using about 50% of the available data. After a short time, the full resolution image is produced (right side). By highlighting the thalamus in the query view (top) we see the affects the high degree of connectivity required to integrate information from the visual system, semato-sensory system, and higher reasoning capabilities of the brain.





Exploring The Connectome:

The connectome represents how connected each part of the cortex is with every other part. We visualize this within the context of fiber tractography. In the image below, a selected cortical patch (in blue) highlights some of the white matter tracts innervating it. Cortical patches connected to it with longer range paths are colored through a user-defined colormap (bottom) to display how connected the regions are. To limit visual clutter, we only highlight a small portion of the tractography information associated with the selected patch.



Summary:

Our system was motivated by the lack of existing visualization techniques capable of interactively and accurately rendering large amounts of EEG, tractography, and other important data modalities simultaneously. The visualization of these data currently assists scientists with the creation of methods to better determine the effects of white matter on simulation routines.

While our system is useful in its current form, additional functionality, such as time-frequency EEG analysis, additional filtering mechanics, and additional interaction metaphors are required to make this a fully featured analysis and visualization tool.

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