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7.5 Flexible Visualization of Sets over Time and Space

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Sets with references to time and space are difficult to visualize. The reason is that multiple aspects of the data must be communicated to the user. In the first place, the set characteristics need to be encoded visually. Moreover, data attributes associated with the set members are important information to be visualized. On top of that, the temporal and spatial frames of reference need to be displayed. Uncertainty of the data might also play a role. Encoding all of these aspects into a single visual representation is typically impractical because the result would likely be complicated to interpret. An alternative is to use multiple views where each view focuses on selected aspects of the data. Yet, connecting findings made in one view to findings made in another view can be a considerable effort. On an elementary level, the user needs to understand how a data object in one view, i.e., in one reference system, relates to another perspective in another view or reference system.

Given the two extremes of fully integrating all aspects in a single representation and separating selected aspects into multiple representations, the working group discussed an alternative option in between, which we call *flexible visualization*. The idea is to bring the two extremes of integration and separation closer together by means of animated transitions. The starting point is to have visual representations that show the data with selected aspects being prioritized and other aspects being attenuated or omitted. For example, a set of movement trajectories is shown on a 2D map to prioritize the spatial aspect of the data. Another view might show the same data as stacked 3D bands above a map to better reveal the data attributes along individual trajectories. Yet another view might show the data as horizontal 2D bands to emphasize the temporal aspect of the data. Now, the core idea of flexible visualization is to have smooth transitions that transform one view into another, rather than showing them as multiple views. That said, flexible visualization aims to balance visual complexity and interaction while providing opportunities to see data and patterns from multiple perspectives.

There are already existing approaches that implement smooth transitions to flexibly animate between views. We recognized the need for a systematic approach to categorizing flexible visualizations in order to gain a better understanding of the potential and limitations

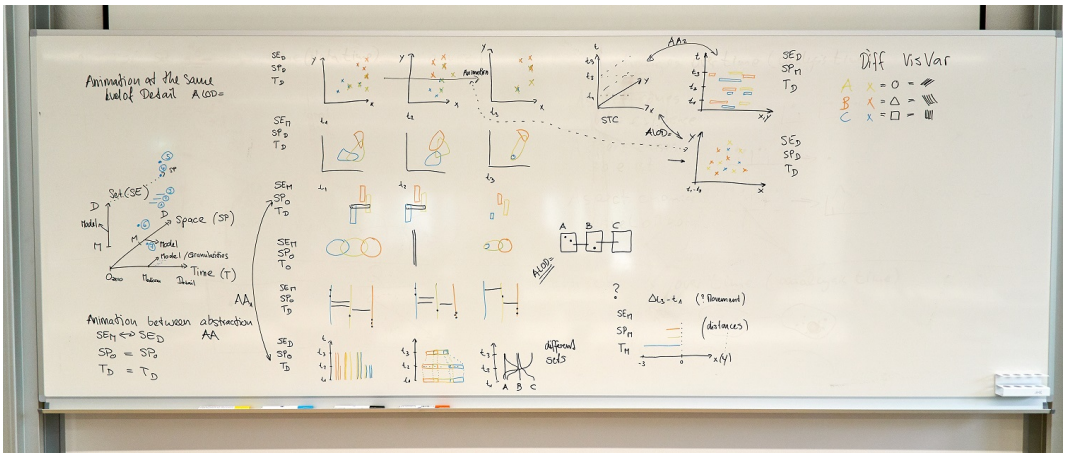

Figure 4 Sketches to systematize flexible visualization.

of augmenting the visual analysis by transitions between discrete visual states. The working group split up into two subgroups to discuss in detail several questions related to flexible visualization, including:

1. Conceptual and technical aspects
   - What are the requirements for flexible visualization?
   - What principle transitions between views are possible and make sense?
   - What topology might flexible visualizations exhibit?
   - Where can smooth transitions operate, in data space or in view space?
   - How can flexible visualization be implemented?
2. Human aspects
   - What are perceptual and cognitive constraints?
   - How should an animated transition be designed?
   - What is the role of interactive user control?
   - Where is the sweet spot between abrupt change and very smooth transitions?
   - Does flexible visualization scale to very large data?

The working group developed first sketches to systematize flexible visualization. Figure 4 shows an example. A first draft of a research publication has been prepared. The goal of this publication is to characterize flexible visualization comprehensively as a viable approach to enhance the visual analysis of complex multi-aspect sets.