

Minimally-immersive Interactive Volumetric Information Visualization

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Abstract

This paper describes a minimally immersive volumetric interactive system for information visualization. The system, SFA, uses glyph-based volume rendering, enabling more information attributes to be visualized than traditional 2D and surface-based information visualization systems. Two-handed interaction and stereoscopic viewing combine to produce a minimally immersive interactive system that enhances the user's three-dimensional perception of the information space, capitalizing on the human visual system's pre-attentive learning capabilities to quickly analyze the displayed information. We describe the usefulness of this system for the visualization of document similarity within a corpus of textual documents. SFA allows the three-dimensional volumetric visualization, manipulation, navigation, and analysis of multivariate, time-varying information spaces, increasing the quantity and clarity of information conveyed from the visualization as compared to traditional 2D information systems.

1. Introduction

This paper describes a new system that demonstrates the value of volumetric visualization techniques in a minimally-immersive interactive system for visualizing information. Most systems for information visualization to date have been 2D or surface-based (e.g., [5, 6]), which fail to capitalize on the human perception system's ability to understand full 3D volumetric space. SFA utilizes full volumetric space for visualizing information through glyph rendering [4].

Several researchers (e.g., [2, 1]) have examined the use of virtual reality environments for visualization; however, very little work exists on applying these techniques to information visualization. Our two-handed minimally-immersive environment goes beyond the earlier work of Feiner and Beshers[1] to include two-handed interaction and volume rendering and has demonstrated the utility of the minimally-immersive approach for increasing the comprehension and understandability of full three-dimensional information spaces.

We have applied these techniques to the visualization of similarities in a document corpus using the Telltale system [3], a dynamic hypertext environment. Telltale provides text indexing via statistical techniques based on n -grams (n character sequences of text) to create links, associating documents that are “similar.”

2. Information Visualization with SFA

SFA uses glyph rendering, allowing the control of glyph attributes for effective visualization. An advantage of glyph rendering is the ability to map characteristics of the information space to attributes of each glyph. Using the glyphs' location (3D), size, shape, color, and opacity allows the comparative display of seven or more information dimensions. Glyph rendering has many of the advantages of direct volume rendering, while avoiding the limitations of iso-surface rendering. The system minimizes the occlusion problems of surface rendering and some volume rendering through the use of glyph rendering, transparency, interactivity, stereo-viewing, interactive manipulation, and interactive volume segmentation and subsetting. SFA also allows time-sequences of data to be animated or sequenced, and several different data sets can be visualized with respect to the same coordinate system, allowing the comparison of trends among related data sets.

SFA provides both a traditional 2D mouse-keyboard interface and a two-handed minimally immersive direct manipulation interface using 3D magnetic trackers with buttons, allowing scene specification and examination as one fluid process. The simultaneous use of these trackers takes advantage of the user's innate proprioceptive knowledge of his/her hands' location in space and allows both hands to be employed in parallel to quickly achieve the desired operation. This two-handed interface uses a natural division of manual labor: the non-dominant (left) hand manipulates the position and orientation of the entire scene and selects the drawing context from a 3D tracker-based hierarchical menu, while the dominant (right) hand selects the 3D volume subset using three-space subsetting and picks glyphs for value displaying and passing it to Telltale.

3. Results

We have applied these visualization techniques to document similarities from Telltale. The document corpus utilized was 1833 articles from the *Wall Street Journal* from September 18, 1989 to October 13, 1989. Similarities to the following “thematic” articles have been generated: Manuel Noriega, Federal Reserve Bank, Foreign Exchange Rate, and Commodity (Gold) Prices.

In Figure 1, the coordinate axes represent similarities to Commodity (X), Foreign Exchange Rate (Y), and Federal Reserve Bank (Z), respectively. The date of the article determined the color, ranging from blue (oldest) to red (most current). Figure 1 displays all 1833 documents, with the most relevant 25 to 30 documents clearly visible. This figure also shows two similarity patterns: the left pattern shows documents discussing both the foreign exchange rate and the Federal Reserve Bank, and the right pattern clearly shows the relationship of commodities (gold prices) and the foreign exchange rate. The interactive stereoscopic manipulation of this data set highlights the similarities of these topics significantly better than 2D visualization. Figure 2 uses the same data with transparency now controlled by similarity to the Noriega article, clearly showing that there are only several articles out of the 1833 displayed discussing the coup attempt against Noriega, the foreign exchange rate, and gold prices.

4. Conclusions and Future Extensions

These visualizations have shown that realtime two-handed interactive volume information visualization can quickly convey trends and multi-dimensional relationships. Careful attribute mapping and interactive volume culling allows quick elimination of useless data for better analysis of relevant information. The two-handed interaction metaphor is a very natural way to interact with volumetric data, and a naive user can become comfortable and proficient using the system within 5 to 10 minutes. The current system permits interactive picking of document glyphs, allowing the retrieval of the document text in the Telltale system for further exploration. SFA provides great flexibility in information mapping for improved perception of relationships and also allows for the real-time interaction, navigation, manipulation, and increased understanding of time-varying multivariate information spaces.

We are currently working on several extensions to the system, including additional mappings of information attributes (dimensions) to glyph attributes, a two-way tighter coupling between SFA and the Telltale system, and improved rendering techniques for glyph rendering.

References

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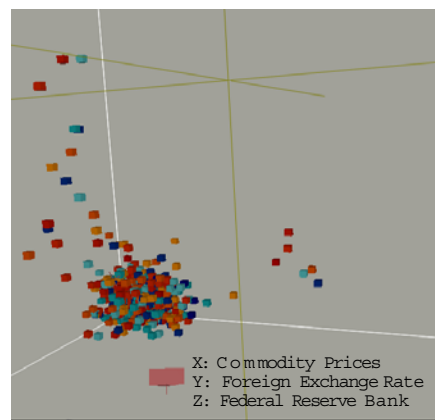


Figure 1. 1833 documents' relationship to commodity prices, foreign exchange, and the Federal Reserve.

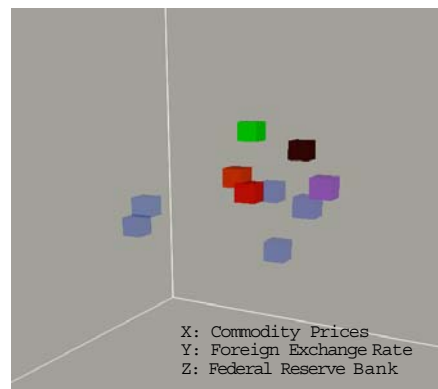


Figure 2. 1833 documents' relationship to commodity prices, foreign exchange, Federal Reserve, and Noriega (transparency).