Interactive Poster: Axes-Based Visualizations for Time Series Data

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Abstract

In the analysis of multidimensional time series data questions involving extremal events, trends and patterns play an increasingly important role in several applications. We focus on the use of Axes-based visualizations(similar to Parallel or Star Coordinates) to aid in the analysis of multidimensional data sets. We present two novel radial visual arrangements of axes - the TimeWheel and the MultiComb. They are implemented as part of an interactive framework called VisAxes. We report our early experiences with these novel design patterns.

1 Introduction

Visualization of multidimensional time-series data is a challenging fundamental problem. One of the tasks at hand is to answer questions involving special events such as large data fluctuations, stock market shocks, risk management and large insurance claims.

For representing a limited number of time steps and limited number of time dependent variables conventional time plots are commonly used[Har96]. Parallel Coordinates [Ins98] and Star Coordinates [Ric95] have been used as effective data exploration tools. They can be termed Axes-based visualization techniques. Their advantage is that they constitute a lossless projection of n dimensional space onto 2-d space. Since these techniques differ depending on the way the axes are mapped onto the screen and on the level of axes interactivity, our aim was to develop a flexible framework, called VisAxes, to support the creation and evaluation of a variety of axes arrangements. VisAxes maps the time series into different radial axes arrangements in the display and provide support for a variety of navigation operations. We introduce two novel radial arrangements, the TimeWheel and the MultiComb, as promising designs for the representation and visualization of multiple data plots.

2 The Framework VisAxes

2.1 Design Criteria

A variety of design criteria had to be met by our framework:

- Emphasis of axes representing time,
- Consideration of multidimensional data analysis,
- Integration of common time plots, since they are easy to understand, and
- Realization of a high degree of interactivity to allow an efficient data exploration.

Conceptually, it is important to separate the design of an individual axis from the arrangement of all the axes on the screen. We focus in this work on radial arrangements of interactive axes with special emphasis on the temporal ones.

2.2 Axes Design & Arrangement

The design and the scale of an axis depend strongly on the type of data that is being mapped onto the axis. (i.e. nominal, ordinal, discrete, or continuous data). In Axes-based visualizations each axis is associated with a data set variable. Usually, axes are scaled from the associated variable's minimum value to it's maximum.

Our framework offers three basic interactive axes. They are applicable to a variety of data sets and can be used in different combinations according to several interaction needs. They are:

- Scroll axis,
- Hierarchical axis, and
- Focus within context axis.

The scroll axis (see Figure 1 left) main use is with variables that have associated a large number of values. It combines a dimension with a slider that can be interactively moved (positioned) on the axis and narrowed or widened allowing a user to choose a section of interest within the variable's domain.

The second type of axis - the hierarchical axis (see Figure 1 middle) - is motivated by [AK02]. It is applicable in the case of hierarchical structured variables. Here the axis is first divided into segments according to the number of nodes in the root level of the hierarchy. Select interactions can be used either to open up more child segments, or to subsume child segments back into a single (parent) segment.

The third type of axis is the focus within context axis (see Figure 1 right). It is of use when a mapping of the entire variable's range is necessary. The focus within context axis is scaled non-uniformly. We apply one of the known magnification transformation functions [Kea98] to the mapping procedure. By doing so, we provide a more detailed view of the data (focus) without loosing the overall view that is provided as the context.

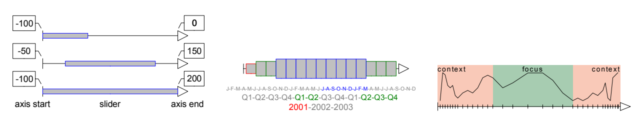

Figure 1 Left: Differently scrolled axes for a variable with minimum value -100 and maximum value 200. The sliders width and location determine the scale of the axis affecting the range of mapped values. Middle: A hierarchical time axis after several steps of interaction. Blue, green, and red frames identify currently visible segments. Right: A non-uniformly scaled focus within context axis combined with a plot of a single variable.

Axes arrangement is a non-trivial task. It has a major impact on the expressiveness and effectiveness of the visualization. Therefore, we distinguish between independent variables (i.e. time) and dependent variables (i.e. time dependent variables). This distinction suggests to treat temporal axes in a special manner in order to emphasize their special role. In the following paragraphs we present several radial axes arrangements which meet our design criteria. Each axis can be any of the presented axis types and it has associated a specific color. Furthermore, addition and removal of axes is allowed during the visualization.

2.3 The TimeWheel

Focusing on the time axis was the main aim when designing the TimeWheel. Therefore, the basic idea of the TimeWheel technique is to present the time axis in the center of the display, and to circularly arrange the other axes around it (see Figure 2). Similar to Parallel Coordinates, a single colored line segment makes a connection between a time value and the corresponding variable's value. From each time value a colored line segment is drawn to each variable axis on the display. By doing so, the dependency on time can be visualized.

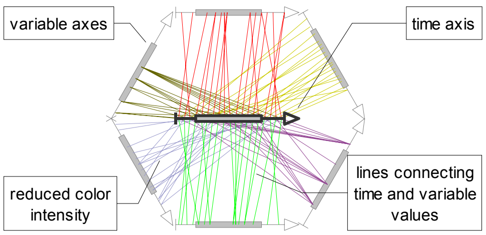

Figure 2 A TimeWheel. Six variable axes are arranged circularly around an exposed centered time axis.

The relations between time and other variable values can be explored most efficiently when the dependent variable axis is laid out parallel to the time axis. Interactive rotation of the TimeWheel is provided so that a user can move his/her axes of interest into such position without visual discontinuities. When an axis is perpendicular to the time axis its visual analysis is very difficult. To alleviate this difficulty we use angle dependent color fading to hide lines drawn between such axes and the time axis (see Figure 3). Additionally, these axes are presented in a lower degree of detail by shortening their lengths. The use of different axes lengths can be viewed in this case as an example of the focus within context approach. By using color fading and length adjustment we avoid overcrowded displays and reduce cluttering. Users familiar with Parallel Coordinates (the time axis can be arranged vertically as well) will see the TimeWheel as an enhancement of particular use for browsing time depending data sets.

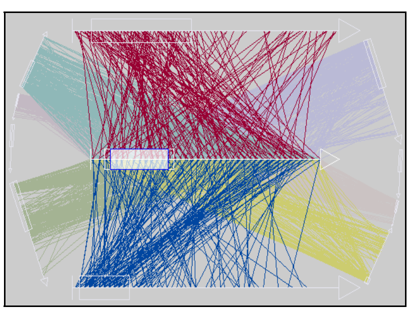

Figure 3 Screenshot of a TimeWheel featuring color fading and axes lengths adjustment.

2.4 The MultiComb

Since common time plots are very efficient for the visualization of a single time dependent variable, our aim for the MultiComb was to make use of this fact for the analysis of multivariate data. The basic idea (inspired by [AK02]) is to arrange the time plots of different variables (one plot for each variable) circularly on the display (see Figure 4). There are two possibilities when arranging the plots. In one case, the variable axes extend outwards from the center of the display and in the second case the time axes extend radially. To avoid overlapping plots the axes are not started at the center of the display. In this way, the center area can be used to present additional information (e.g. a spike glyph for value comparison or an aggregated view of "past" values).

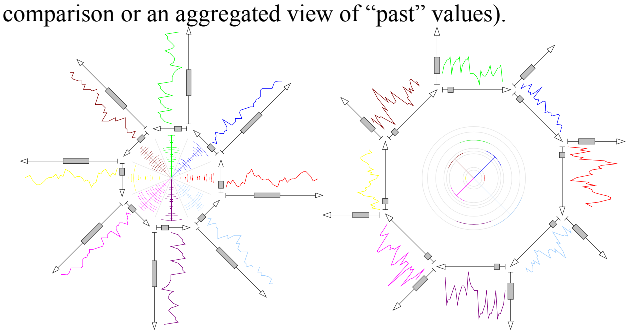

Figure 4 Two MultiCombs. On the left, time axes extend from the center; The center area displays an aggregation view. The figure on the right shows time axes arranged circularly and the center are contains a spike glyph representing the different variable values that correspond to a chosen time value.

3 Conclusion

Inventing useful design patterns for multidimensional time dependent data is a very challenging undertaking. For the visualization of such data we suggested two novel radial arrangements of axes - the TimeWheel and the MultiComb. These radial arrangements in conjunction with our interactive axes - scroll, hierarchical, and focus within context - offer an interesting alternative to more conventional embeddings.
The presented techniques have been implemented in an object-oriented and Internet capable framework called VisAxes. The framework can be used for easy creation and evaluation of different axes arrangements.

References

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