Interactive Poster: 3D Axes-Based Visualizations for Time Series Data

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ABSTRACT

In this work we present novel axes-based visualizations that can be used to explore and analyze multivariate time series data. We propose different types of interactive axes, which in turn can be used to compile novel 3D axes arrangements. The proposed axes-based visualizations utilize an exposed central time axis around which axes representing time-dependent attributes are arranged. Each depending attribute is visually associated with the time axis by means of different types of drawings.

1 INTRODUCTION

The analysis of time series data is a fundamental task addressed by information visualization. Usually time series can be represented using diagram techniques [1]. However, diagrams are only capable of representing a limited number of time-dependent attributes, and it is mostly required that the attributes to be visualized have a common, or at least a similar value range. Therefore, diagram techniques do not provide a general solution for presenting multiple time-dependent attributes with different value ranges. Hence, in recent years much effort has been spent on developing visualization techniques for time series data. An overview of such techniques can be found in [2]. Nevertheless, the visualization of multiple time-dependent attributes remains a challenging problem.

On the other hand, the visualization of multivariate data is not a new topic to information visualization researchers. A variety of approaches have been developed which are capable of visualizing multiple attributes. Prominent examples are Parallel Coordinates [3] and Star Coordinates [4], which have long been used as effective data exploration tools. These techniques have in common that they map data values to positions on axes which represent the attributes' value ranges. A data tuple (i.e. a data entry consisting of one value for each attribute) can then be represented by line segments connecting the respective positions on each axis. The advantage of these approaches is that they allow an interactive exploration of an n-dimensional data space using a 2-dimensional display space.

Therefore, it was our goal to combine the advantages of time series visualization techniques with the advantages of axes-based techniques for multivariate data. For achieving this goal, we have developed a general axes-based framework [5] that integrates novel interactive axes as well as novel axes arrangements. Furthermore, we mentioned some concepts for extending the 2D approach to 3D [6]. In the work presented here we want to introduce our novel 3D visualization techniques for multivariate time series data. We introduce novel 3D axes arrangements, and furthermore, present intuitive interaction methods for easy data exploration and navigation.

2 AXES-BASED VISUALIZATION IN 3D

The requirements and design goals for this work are the same compared to our 2D approach [5]:

- 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.

Furthermore, it is necessary for the 3D approach to take into account issues concerning the 3D representation space. As such, the problem of hidden information must be considered, and furthermore, difficulties that may arise when using a 2D pointing device (e.g. a mouse) to navigate the 3D representation space must be addressed.

2.1 Axes Design

Usually, axes are static representations of an associated attribute's value range. Although, in our framework such axes can be used, we also provide special interactive axes. These are scroll axes, and focus&context axes [6]. Scroll axes can be used to directly navigate an attribute's value range. This can be achieved by moving, widening, or narrowing a slider provided with a scroll axis. Focus&context axes can be used to create a non-linear mapping of an attribute's value range to an axis. A special slider can be used to interactively adjust the focus position as well as the amount of magnification.

These axes can now be extended to 3D axes. For doing so, the respective sliders have been extended to 3D geometry that can be picked with a pointing device. Furthermore, the axes have been extended with an average marker which gives a visual clue of the average of the values currently represented on an axis.

2.2 3D Axes Arrangements

The extended 3D axes can now be used to create novel 3D axes arrangements. However, arranging axes in a three dimensional viewing space to achieve expressive visualizations of multiple time-dependent attributes is not a trivial task. Therefore, we have experimented with a variety of axes arrangements. The most promising ones shall be presented here. All arrangements have in common that they arrange axes which represent dependent attributes around a common axis which represents an independent attribute (e.g. time). Furthermore, semi-transparent data wings are used to allow an easy separation of attributes in the presentation.

3D Time wheel

The 3D Time wheel is a consequential extension of our 2-dimensional Time wheel. A centrally exposed axis represents the time attribute, radially arranged are axes representing time-dependent attributes (cf. Figure 1). By this arrangement, each time-dependent attribute is visually associated with the time axis, and hence, the time-dependency can be easily analyzed. Though the 3D Time wheel originally addresses time-dependent data, it can also be used for visualizing the dependency or correlation of multiple attributes with respect to an arbitrary reference attribute in the center.

3D Multi comb

The intention for the 3D Multi comb was to increase the user acceptance by integrating commonly accepted time plots. Therefore, the axes are arranged in a way so that each plot is

located circularly around a commonly shared time axis (cf. Figure 2). By this arrangement, multiple time plots have been combined in a way that allows intuitive interpretation of the represented data.

3D Kiviat tube

The third arrangement to be presented is the 3D Kiviat tube. This arrangement is inspired by [7]. Here the axes are arranged similarly to the 3D Multi comb. However, in this case no plots are drawn, but for each time step a surface is rendered representing a Kiviat diagram for the respective time step (cf. Figure 3). By this, the detection of correlation among the represented attributes is supported without loosing the focus on time-dependency.

2.3 Interaction

To fully exploit the capabilities offered by the proposed 3D arrangements, intuitive interaction techniques must be provided. This can be achieved by incorporating usual 3D navigation techniques or virtual trackballs as described in [8]. Furthermore, we have integrated a special interaction metaphor called "folder style". By this it is meant that all arrangements can be opened up like a folder (cf. Figure 4). By doing so, two adjacent attributes can be analyzed in full detail. Due to the semi-transparency of the data wings, other attributes still contribute context information.

3 Conclusion

In this work we present promising 3D arrangements of interactive axes to achieve expressive visualizations of multivariate time series data. The presented techniques address different visualization task such as detection of temporal correlation (3D Time wheel), comprehension of temporal evolution (3D Multi comb), and detection of correlation among attributes (3D Kiviat tube). The presented arrangements are implemented in a prototype software which allows experimenting with further 3D arrangements of axes. As an extension it is planed to integrate strategies for automatically mapping attributes to axes. This can be achieved, for instances, by utilizing similarity or entropy-based approaches. In the future user experiments must be conducted to fully judge the effectiveness of the proposed axes arrangements.

References

[1] Harris, R.L.: *Information Graphics: A Comprehensive Illustrated Reference.* Atlanta, Georgia: Management Graphics, 1996.

[2] Müller, W.; Schumann, H.: Visualization Methods for Time-dependent Data – An Overview. *Proc. Winter Simulation Conference*, New Orleans, 2003.

[3] Inselberg, A.: A survey of parallel coordinates. In Hege, H.-C.; Polthier, K. (eds): *Mathematical Visualization*, Heidelberg: Springer Verlag, 1998.

[4] Richards, L.G.: Applications of Engineering Visualization to Analysis and Design. In: Gallagher, R.S. (ed): *Computer Visualization*. Boca Raton: CRC Press, 1995.

[5] Tominski, C., Abello, J., Schumann, H.: Interactive Poster: Axes-based Visualizations for Time Series Data. *Proc. IEEE Symp. on Information Visualization*, Seattle, 2003.

[6] Tominski, C., Abello, J., Schumann, H.: Axes-Based Visualizations with Radial Layouts, *Proc. ACM Symp. on Applied Computing*, Nicosia, 2004.

[7] Hackstadt, S.T.; Malony, A.D.: Visualizing Parallel Programs and Performance. *IEEE Computer Graphics and Applications*, Vol. 15, No. 4, 1995.

[8] Henriksen, K.; Sporring, J.; Hornbæk, K.: Virtual Trackballs Revisited. *IEEE Transactions on Visualization and Computer Graphics*, Vol. 10, No. 2, 2004.

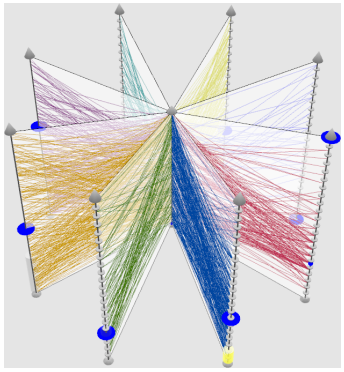

Figure 1 A 3D Time wheel representing six time-dependent attributes in the periphery of a central time axis.

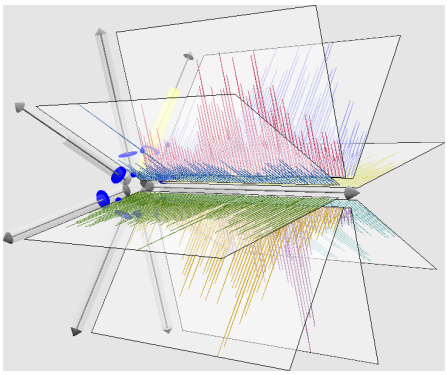

Figure 2 A 3D Multi comb representing eight time-dependent attributes as plots with respect to a common central time axis.

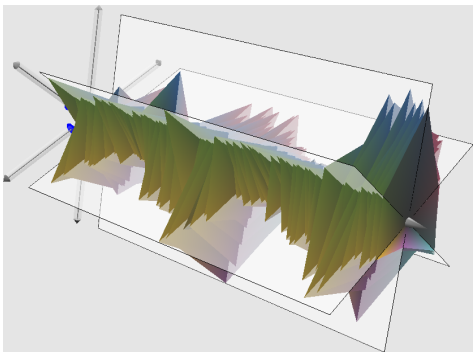

Figure 3 A 3D Kiviat tube visualizing six attributes with respect to a central time axis.

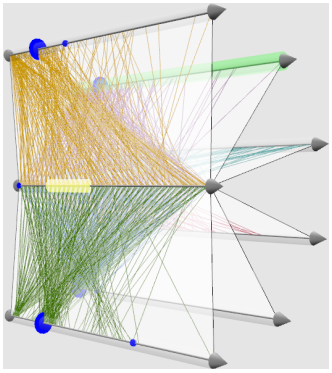

Figure 4 A 3D Time wheel opened up in "folder style". The Time wheel has been slightly rotated to demonstrate the effect.