A Sketch+Fisheye Interface for Visual Analytics of Large Time-Series

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ABSTRACT

This paper develops a sketch+fisheye interface supporting natural HCI in visual anal sis of lar e multi le time-series. The sketch-based fisheye can help analysts to efficiently analyze the high density temporal data at multi-scale magnification level while maintainin the entire tem oral context. The sketch-based multiple time-series query provides a natural HCI technique which is especially suitable for visual analysis of temporal curves. This sketch+fishe e interface will contribute to minimize the HCI cost and keep the consistency of thinking in visual analysis, thus enhancing analysis efficiency.

Keywords: Time-series visualization, human-computer interaction, sketch, fisheye, visual analytics.

Index Terms: H.5.2 [Information Interfaces and Presentation]: User Interfaces—Graphical user interfaces (GUI)

1 INTRODUCTION

Large-scale time-series data visualization [1] usually leads to a user interface with high density visual metaphors in a limited screen, making it difficult to carry out visual analytics. In most common time-series visualizations represented as timeline-based multiple curves, analysts often face the following challenges. One problem is that timeline is often very long, thus analysts are provided with a high-level overview of the entire temporal datasets in a quite coarse-grained time scale. Analysts usually need to explore more fine-grained details in a potentially interesting time region. The typical resolution is to offer linked views supporting Overview+Detail interaction. The isolated views, however, usually keep the analysis area separate from continuous temporal contexts. In addition, analysts always have to switch attention between different views, thus leading to discontinuity of thinking in a visual analysis process. This problem could be more efficiently solved by introducing fisheye and Focus+Context (F+C) [2] interaction into time-series analysis.

Another challenge lies in interaction with numerous overlapping and crowded curves, because analysts often feel difficult to locate and discover desired curves that have special pattern in a mess. Most current methods make use of the WIMP (Windows, Icons, Menus and a Pointer) interface supporting interactive exploration such as zoom and filter. But the redundant WIMP operations on interface often interrupt the reasoning process, thus increasing the cost of analysis. Recent research on post-WIMP such as pen and touch interaction [3] for information visualization revealed that natural interaction techniques can obviously improve visual analysis efficiency. Since the freeform curves in time-series visualizations can be easily drawn by pen strokes, sketch-based interface is particularly suitable for time-series analysis. Analysts may feel more natural to explore the curves such as detecting similar temporal pattern by sketching a polyline on the screen.

To address these issues we design a Sketch+Fisheye interface for interactive visual analysis of dense multiple time-series. In this interface, analysts can sketch circles on the timeline to generate multiple fisheyes, enabling F+C analysis in different time scale. Also, analysts can sketch a curve freely on the interface to allow quickly similar pattern detection and outlier analysis.

2 RELATED WORK

F+C paradigm and derived techniques come from generalized fisheye view [2] which can magnify an interested focus area while retaining the integrity and consistency of the context in a single display space. Fisheye allows analysts to think and reason in a consistent context, which is most important to temporal relationship analysis. Compared to multiple views that employ Overview+Detail paradigm, F+C can help minimize working memory switching between different display spaces, allowing analysts to keep continuity of thinking during interaction, thus improving the analysis efficiency. For example, SignalLens [4] provided F+C lens for inspecting dense signal details in the context of the entire amplitude modulated electronic signal trace, and it is mainly towards temporal analysis for single long time-series. CloudLines [5] applied lens distortion methods to allow magnifying interested compressed area of temporal clusters, supporting F+C analysis of multiple time-series of event episodes. Usually, these interactive fisheye views are activated and manipulated with WIMP interface.

As human-computer interaction (HCI) plays an essential part in visual analytics, some research works put the emphasis on post-WIMP natural interaction techniques that incorporate everyday experiences. Walny et al. [3] discussed the effect of pen and touch interaction in information visualization, and indicated that pen- and touch-based interactions can enhance people's analysis capabilities. As a popular representative of post-WIMP, sketch-based interface has a natural advantage in describing freeform diagrams such as curves, which makes sketch a promising interaction technique in visual analysis of time-series.

3 SKETCH+FISHEYE INTERFACE FOR TIME-SERIES ANALYSIS

3.1 Sketch-based Multi-Scale Timeline Fisheye

Fig. 1 shows the interface of sketch-based multi-scale timeline fisheye, which is mainly used to help analysts to analyze multi-scale time-varying curves in a highly compressed time frame while retaining the entire temporal context.

Fig. 1 (a) depicts the overview of temporal visualization of stock market fluctuations of multiple stocks from 1985 to 2009. The multiple stocks are mapped to time-varying curves with different colors. A vast number of values of the stocks' prices, spanning a long time period of 25 years (300 stocks with about 1 million items), make it difficult to visualize more details in the high density interface space. If an analyst want to explore the detailed fluctuations in a small time frame, (s)he can sketch a circle on the time axis. As depicted in Fig. 1 (b), the stroke will be recognized as a fisheye activation command, and then the selected segment of the timeline as well as the time-related curves will be stretched horizontally. At the same time, the other regions on the timeline will be compressed. Also, the analyst can continue to draw circles within the focus area on the axis to drill down to analyze more details at multiple scales. In addition, this interface

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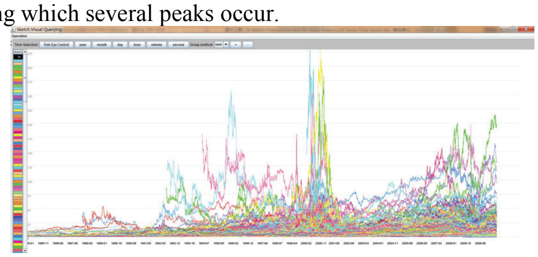
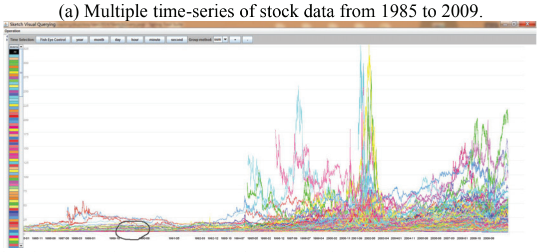
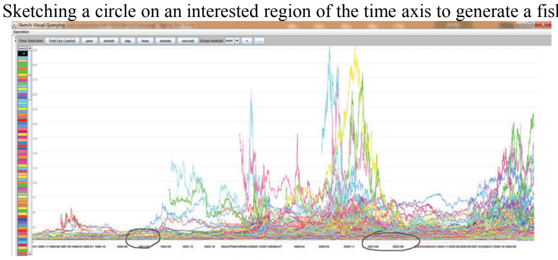
allows analysts to sketch multiple fisheyes on the axis. As shown in Fig. 1 (c), the analyst draws another circle on the time frame during which several peaks occur.



(a) Multiple time-series of stock data from 1985 to 2009.



(b) Sketching a circle on an interested region of the time axis to generate a fisheye

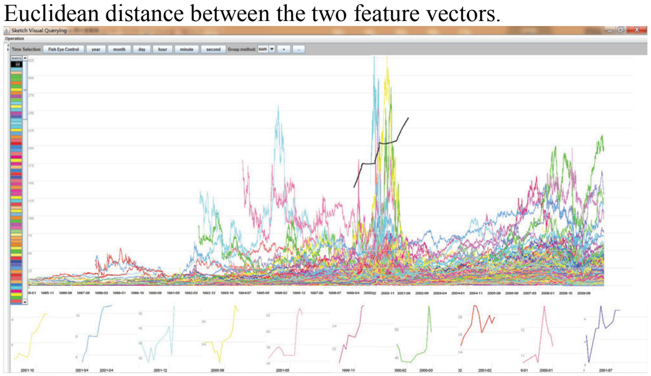


(c) Sketching multiple fisheyes in the time axis

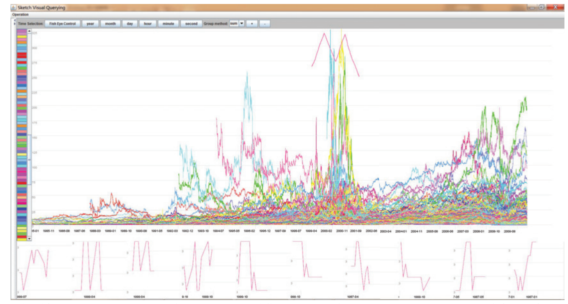
Figure 1: Sketch-based multi-scale timeline fisheye.

3.2 Sketch-based Multiple Time-Series Query

Fig. 2 shows the sketch-based multiple time-series query interface, which provides support for analysts to detect and analyze the underlying time-varying curves with specific patterns in the overlapping visual elements with high density. An analyst can sketch an ink stroke within a specific time frame on the two-dimensional visualization space, and then the curves that contain partial shapes similar to the stroke during the given time period will be matched and visualized at the bottom of the interface. The stroke feature computing and curve matching is based on the approach in [6]. Seven features, including the characteristics of initial angle and bounding box, are used to define the structure of a stroke as well as a curve. The similarity is measured by the Euclidean distance between the two feature vectors.



(a) Similar pattern query in multiple curves from 1999 to 2001 with a sketched stroke in black ink



(b) Similar pattern query in one specific curve from 1999 to 2001 with a sketched stroke in red ink

Figure 2: Sketch-based multiple time-series query.

The interface provides two sketch query modes differentiated by ink color, which enables an analyst to detect the similar pattern in all temporal curves or only one specific curve. As shown in Fig. 2 (a), if the analyst chooses the black ink, the interface will inspect all stocks within the time frame specified by the sketched stroke, and the matched curves are then listed below. Fig. 2 (b) shows the other mode in which the stroke is drawn in red ink, and only the stock curve rendered in red color will be analyzed. Similar to this example, an analyst can choose any one of the colors listed on the left, except black, to analyze a specific stock.

4 Conclusion and Future Work

This paper develops an interface combining sketch and fisheye for natural HCI in visual analysis of large multiple time-series. This sketch+fisheye interface will contribute to minimize the HCI cost and keep the consistency of thinking in visual analysis, thus enhancing analysis efficiency. The future works include improving the stroke matching algorithm and expanding this work to a sketch-based system for visual analytics of large time-series.

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