

INTERACTIVE ANALYSIS OF MULTIDIMENSIONAL DATA ON THE WEB BY USING TIME-TUNNEL

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Abstract: In recent years, the Internet has become popular in various application fields so that a huge number of data records are generated and stored on the web. In this situation, we need any tool that helps us to analyze such multidimensional data for obtaining new findings from those data. In this paper, we introduce a visual and interactive analysis tool for multidimensional data called Time-tunnel. Time-tunnel visualizes any number of time series numerical data records as individual charts each of which is displayed on an individual rectangular plane called data-wing in a 3D virtual space. Through direct manipulations on a computer screen, the user easily puts more than two data-wings overlapped together to compare their charts in order to recognize the similarity or the difference among those data records. Simultaneously a radar chart among those data at any time point is displayed to recognize the similarity and the correlation among them. This time, the authors extended Time-tunnel to make it available on the web and this paper clarifies the usefulness of web-version Time-tunnel by showing practical analysis examples.

1 INTRODUCTION

This paper treats a visual and interactive analysis tool for multidimensional data called Time-tunnel developed by our research group (Akaishi and Okada, 2004; Akaishi and Okada, 2005). This time, we extended Time-tunnel to make it available on the web and this paper clarifies the usefulness of web-version Time-tunnel by showing practical analysis examples.

Time-tunnel visualizes any number of time-series numerical data records as individual charts in a virtual 3D space. Each chart is displayed on a rectangular plane called data-wing. The user easily puts more than two different data-wings overlapped together to compare their data represented as charts in order to recognize the similarity or the difference among them. Simultaneously a radar chart among those data at any time point is displayed in the same 3D space to recognize the similarity and the correlation among them. However, in Time-tunnel, only one chart is displayed on one data-wing. If there are a huge number of time-series numerical data records, the user has to prepare accordingly such a huge number of data-wings and practically it becomes impossible to interactively manipulate

them. To deal with this problem, we enhanced the functionality of Time-tunnel to enable it to display the Parallel Coordinates on each data-wing (Notsu et al., 2005). Due to this functionality enhancement, the user can visually analyze a huge number of time-series numerical data records through interactive manipulations on a computer screen. Furthermore, it becomes available for the visual analysis of multi-dimensional data, i.e., database records with a huge number of attributes by preparing multiple data-wings, dividing multi-attribute data into several sets by attributes, and displaying each set of data as Parallel Coordinates on each data-wing.

In recent years, the Internet has become popular in various application fields so that a huge number of data records are generated and stored on the web. In this situation, we need any tool that helps us to analyze such a huge number of data records effectively, e.g., visually and interactively, on the web. This time, we extended Time-tunnel to make it available on the web.

The remainder of this paper is organized as follows. First of all, Section 2 describes related work and points out the difference of our tool from theirs. Section 3 introduces details of Time-tunnel and its Parallel Coordinates version. Then, Section 4

describes implementation of Time-tunnel as a web application. Section 5 presents data analysis examples using web-version Time-tunnel. Finally we conclude the paper in Section 6.

2 RELATED WORK

For the visualization of multidimensional data, Inselberg and Dimsdale introduced Parallel Coordinates (Inselberg and Dimsdale, 1990), which visualizes multiple data records as multiple poly-lines on the same 2D plane at the same time. After their proposal of Parallel Coordinates, many modified versions having a variety of additional features were proposed. For instance there is method (Artero, 2004, Graham, 2003; Fua, 1999; Johansson, 2005; Siirtola, 2000; Hauser, 2002) that draws poly-lines in adequate colors and transparency levels according to their crowding densities, and there is a similar method for the same purpose (Graham, 2003) that draws curbed lines instead of poly-lines to indicate high crowding dense attribute values. Although we have not implemented these techniques yet, it is possible technically to introduce them into our Parallel Coordinates version of Time-tunnel. We are supposed to do that. Also, there is a unique proposal (Johansson, 2005) that visualizes Parallel Coordinates by vertical axes each stands on a circle in a 3D space. One more vertical axis stands at the center of the circle. This axis corresponds to the user selected attribute of database records and other vertical axes standing on the circle correspond to several attributes most strongly related to the center axis attribute. This proposal is interesting but is not directly related to our proposed system. Our proposed Parallel Coordinates version of Time-tunnel visualizes multiple charts like Parallel Coordinates on one individual rectangular plane. Time-tunnel originally provides multiple data-wings in a virtual 3D space so that if the user has a huge amount of data records, he/she can analyze them by separating into several groups using multiple rectangular planes. This is the one advantage of our Parallel Coordinates version of Time-tunnel.

Another popular data analysis method is based on star chart or radar chart. As the similar tools, there are Star Glyphs of XmdvTool (Ward et al., 1994) and Stardimates Tool (Lanzenberger and Miksch, 2003). Stardimates Tool has combined feature of Parallel Coordinates and Glyphs (Ward et al., 1994). Our Time-tunnel has combined feature of Parallel Coordinates and star chart (radar chart) visualization tool with interactive interfaces. Moreover, Time-

tunnel has also aspects as a multimedia presentation tool. These points are further differences of our Parallel Coordinates version of Time-tunnel from the above visual analysis tools.

3 TIME-TUNNEL

In this section, we introduce original Time-tunnel and Parallel Coordinates version of Time-tunnel. First of all, we describe system configuration of original Time-tunnel, its components and how Time-tunnel works for the analysis of multidimensional data, especially multiple time-series numerical data. After that, we show Parallel Coordinate version of Time-tunnel.

3.1 System Configuration

Time-tunnel consists of three main types of components, i.e., data-wing, time-plane and time-bar. Parent-child relationships among data-wings, time-planes and time-bar are as shown in Figure 1. Rotation-bar works as the hinge and the parent of data-wing, and time-bar is the parent of each Rotation-bar.

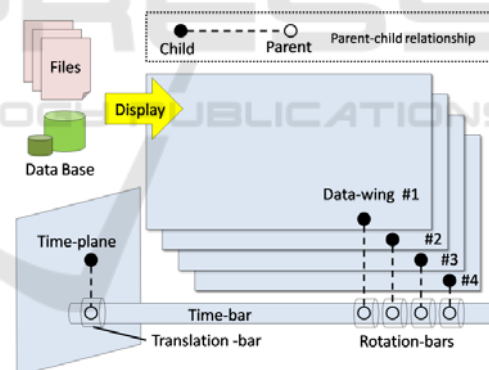


Figure 1: Component structure of Time-tunnel.

3.1.1 Data-wing

Data-wing has a shape like a sheet. It displays one multidimensional data, one time-series numerical data, as a chart on its sheet. For the visualization of multiple data, the user can use multiple data-wings as he/she wants. Each data-wing is connected to time-bar by its hinge. The hinge is also another component that has a rotation functionality called rotation-bar. Therefore, by rotation operations on data-wings, the user can put multiple charts overlapped together to compare them. Each time-series numerical data of each data-wing is sent to

time-bar through rotation-bar. Data-wing keeps one time-series numerical data. It makes a chart from the data and displays the chart on its surface.

3.1.2 Time-plane

Time-plane also has a shape like a sheet. Time-plane is connected to time-bar perpendicular to data-wings and used for displaying a radar chart. Figure 2 shows its detail of the radar chart. Its position data is sent to time-bar to specify a time of data among charts to be displayed as a radar chart. Actually time-plane is connected to time-bar through translation-bar. Time-plane moves along time-bar by the user manipulations on the translation-bar, because the translation-bar is the parent of time-plane.

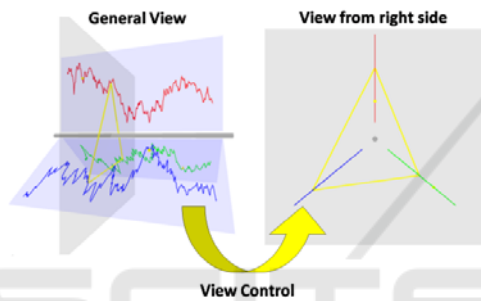


Figure 2: Radar chart display.

3.1.3 Time-bar

Time-bar has a thin, long cylindrical shape. Time-bar works as a time pivot of data-wings. It collects multiple time-series numerical data from each data-wing and displays a radar chart on one of time-planes.

3.2 Parallel Coordinates Version of Time-tunnel

When visualizing a large number of time-series numerical data records, the user has to prepare exactly the same number of data-wings. To deal with this problem, we extended the functionality of data-wing as explained in the following.

Figure 3 shows Parallel Coordinates version of Time-tunnel. We extended data-wing to enable it to display more than two time-series numerical data records, i.e., multiple database records as multiple charts, in it like Parallel Coordinates. Even if there are a huge number of database records to be visualized, the user can divide them into several groups and assign each group to one of the multiple data-wings of the same Time-tunnel. Since Time-

tunnel has multiple data-wings and displays multiple Parallel Coordinates using those data-wings, it is easy to separate database records shown on one data-wing and to visualize each of them on each of the multiple data-wings.

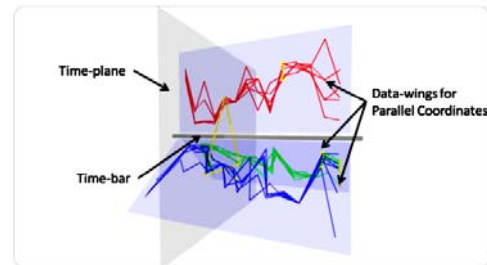


Figure 3: Parallel Coordinates version of Time-tunnel.

In this way, the user can visualize a huge number of database records using Parallel Coordinates version of Time-tunnel. The user can select one record that he/she wants to analyze in each data-wing and the selected chart is soon highlighted. Since the user can rotate and put any data-wings overlapped together, he/she can compare his/her selected records by looking at highlighted charts. Furthermore, a radar chart among the selected charts can also be displayed similarly to original Time-tunnel.

4 IMPLEMENTATION OF TIME-TUNNEL AS A WEB APPLICATION

The original Time-tunnel is developed using IntelligentBox (Okada and Tanaka, 1995) which is a constructive visual software development system for interactive 3D graphic applications. IntelligentBox applications run only on the IntelligentBox system so that the user needs to install IntelligentBox in order to use original Time-tunnel.

Web version of Time-tunnel is realized as a flash content by ActionScript programming with the use of Papervision3D ActionScript library. The user can use Time-tunnel through a web browser in which Adobe Flash Player plug-in is installed. So, it is possible to provide Time-tunnel functionalities as one of the SaaS (Software as a Service) applications. In addition, Web version of Time-tunnel has JavaScript API to allow the user to embed Time-tunnel functionalities in his/her own web page and MashUp is also possible. The functions provided by the Time-tunnel API are specifically to create new Time-tunnel in a 3D virtual space, to add new data-

wing to current Time-tunnel, to read database records and to assign them to data-wings, and so on.

5 DATA ANALYSIS EXAMPLE

This section introduces data analysis example. Figure 4 shows a web service example consisting of two Time-tunnels. This web service analyzes company information. One of the Time-tunnels shown in the left part of Figure 4 has multiple data-wings each of which displays multiple Parallel Coordinates. Each data-wing of the Time-tunnel displays database records of each of the three kinds of Japanese companies, i.e., finance companies, industry companies, and food stuff companies. These database records have fourteen types of attributes, e.g., head-count, number of recruitment, beginning salary, and so on.

Another Time-tunnel shown in the right part of the figures displays time-series stock data categorized into three on three data-wings put overlapped together. In this way, the user can analyze database records interactively on the web.

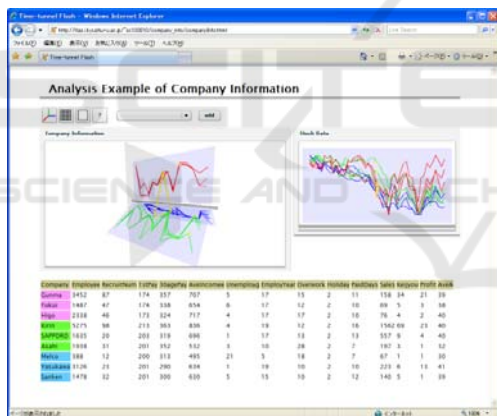


Figure 4: Web service example to analyze company information by using two Time-tunnels together.

6 CONCLUSIONS

In this paper, we introduced interactive visualization tool called Time-tunnel and proposed web version of Time-tunnel to analyze multidimensional data on the web. Then, we described its usefulness by showing a practical data analysis example using real database records.

As future works, we will propose a new analysis tool that is realized as a combination of Time-tunnel and another web API. We also have to evaluate the

usefulness of Time-tunnel by consulting actual users who use it.

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