Time-tunnel: Visual Analysis Tool for Time-series Numerical Data and Its Combinational Variation

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Abstract

This paper treats a visual analysis tool called Time-tunnel and its various combinational usages. Time-tunnel is a visualization tool for time-series numerical data. Each data record is displayed as an individual chart in a virtual 3D space. Through direct manipulations on a computer screen, the user can visually and interactively analyse multiple data records. Strictly speaking, the user can compare several data records by overlapping multiple charts together through manual operations. Furthermore, the user can find out the similarity or the correlation among those data records by the display of their radar char at any time point and correlation points in the same 3D space.

In this paper, how Time-tunnel works for the analysis of time-series numerical data has been introduced and especially two typical combinational usages of Time-tunnel have been proposed to show its usefulness.

Key words
Visualization tool, Analysis tool, Multi-charts tool, *Time-tunnel*, *IntelligentBox*

1. Introduction

This paper treats a visual analysis tool called *Time-tunnel* for time-series multidimensional, numerical data. Recently, computers are being used everywhere for the management and the control of various types of systems and human activities, and then, as a result of such computer work, various kinds of time-series numerical data are recorded and stored. At present we have a huge amount of digital numerical data all over the world, e.g., economical data. To analyze such data is important, especially for economists or historical scientists. We need a tool that helps us to analyze such data. We have already proposed a new data analysis tool called *Time-tunnel* [1].

Time-tunnel visualizes any number of time-series numerical data records as individual charts in a virtual 3D space. The user can easily put more than two different charts overlapped together to compare them and recognize the similarity or the difference among these data records. A radar chart among these data records at any particular time point can be displayed simultaneously in the same 3D space to recognize the similarity and the correlation among them. In this way, the user can visually analyze multiple time-series numerical data records through interactive manipulations on a computer screen.

Time-tunnel is developed using *IntelligentBox*[2]. *IntelligentBox* is a 3D graphics software development system and provides various functionalities as software components called *boxes*. Since *Time-tunnel* is realized as the composition of several *boxes* and each *Time-tunnel* works individually, it is possible to use multiple *Time-tunnels* simultaneously with different combinations. In this paper, we introduce how *Time-tunnel* works and how many kinds of its combinational usages exist for the analysis of time-series numerical data. We propose two typical combinational usages of *Time-tunnel.,* i.e., its parallel combination and hierarchical combination, to show the usefulness of our *Time-tunnel*.

[Related work]

For the visualization of multidimensional data, Inselberg and Dimsdale introduced *Parallel Coordinates* [3], 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 [4, 5, 6, 7, 8]. Another popular data analysis method is based on *star chart* or *radar chart*. Other similar tools are *Star Glyphs* of *XmdvTool* [9] and *Stardinates Tool* [10]. *Stardinates* Tool has combined feature of *Parallel Coordinates* and *Glyphs* [9].

Our *Time-tunnel* has combined features of Parallel Coordinates and star chart (radar chart) visualization tool, which have been described in Sec. 2. Although we cannot

describe in this paper due to the space limitation, *Time-tunnel* has also aspects as a multimedia presentation tool [1]. Furthermore, it is possible to use multiple *Time-tunnels* simultaneously with different combinations. These points differentiate *Time-tunnel* from other visual analysis tools.

The remainder of this paper is organized as follows. Section 2 describes details of *Time-tunnel*. Section 3 introduces two typical combinational usages of *Time-tunnel*. Finally we conclude the paper in Section 4.

2. *Time-tunnel*

In this section, we describe the system configuration of *Time-tunnel* and the role of each of its components. We also show how original, single *Time-tunnel* works for the analysis of multiple time-series numerical data.

2.1 System configuration

Time-tunnel mainly consists of three types of *boxes*, i.e., *data-wing, time-plane* and *time-bar*. Figure 1 shows its component structure and the parent-child relationships among its components, i.e., *data-wings*, *time-planes, time-bar*, and other required *boxes*. Figure 2 shows a screen snapshot of actual *Time-tunnel.*

(1) ***Data-wing*** has a shape like a sheet and displays one time-series numerical data records as a chart on its sheet. For the visualization of multidimensional data, the user can use as many *data-wings* as he/she require. Each *data-wing* is connected to *time-bar* by its hinge. The hinge is also a *box* that has a rotation functionality called *RotationBox*. Therefore, by rotation operations on *data-wings*, the user can put multiple charts overlapped together to compare them. The time-series numerical data of each *data-wing* is sent to *time-bar* through *RotationBox* to ask *time-bar* activate it for displaying a radar chart.

(2) ***Time-plane*** also has a shape like a sheet and is connected to *time-bar* vertically to *data-wings*. Usually three *time-planes* are necessary as shown in Figure 1. Two *time-planes* are used to specify a time region, i.e., a begin time point and an end time point. Correlation points between any two adjacent charts are displayed inside the time region. The remaining *time-plane* is used for displaying a 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 *ExpandBox*. Then, *Time-plane* moves along *time-bar* by the user manipulations.

(3) ***Time-bar*** has a thin, long cylindrical shape and works as a time pivot of *data-wings*. It collects multiple time-series numerical data records from each *data-wing* and displays a radar chart on one of the *time-planes*. It also displays correlation data between any two adjacent *data-wings* as scattered points in the time region specified by the two remaining *time-planes* as shown in Figure 2.

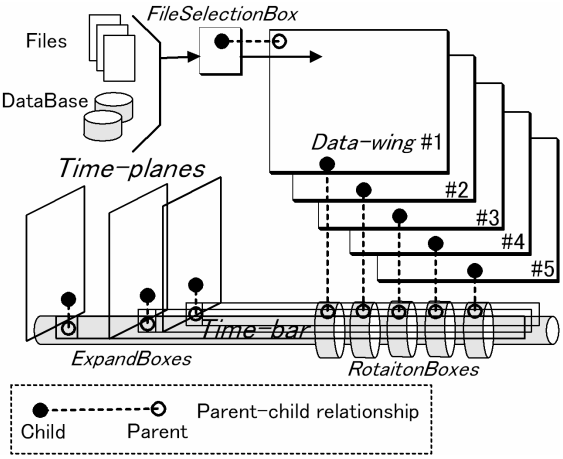

Fig. 1. System components of *Time-tunnel*.

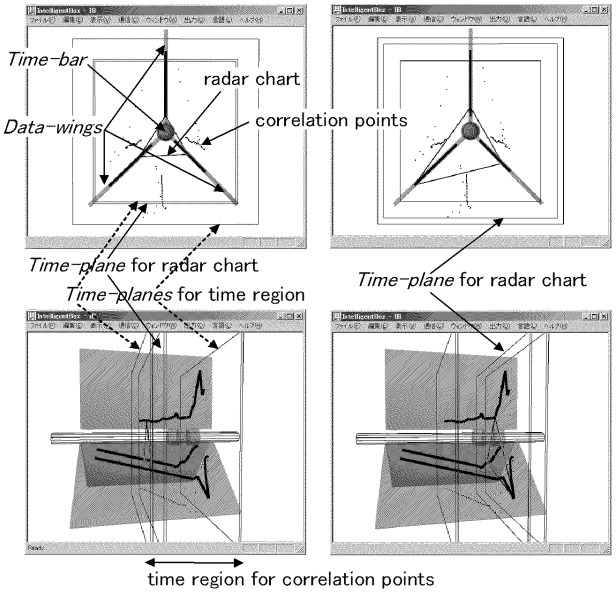

Fig. 2. Screen snapshot of *Time-tunnel.*

3. Combinational Variation of *Time-tunnels*

In this section, we propose combinational usages of multiple *Time-tunnels* to show the usefulness of *Time-tunnel*. There are two typical combinations, the first one is parallel

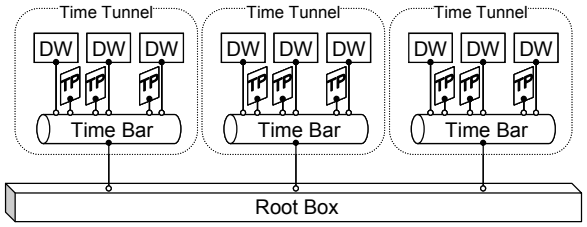

Fig. 3. Parallel combination of *Time-tunnels*.

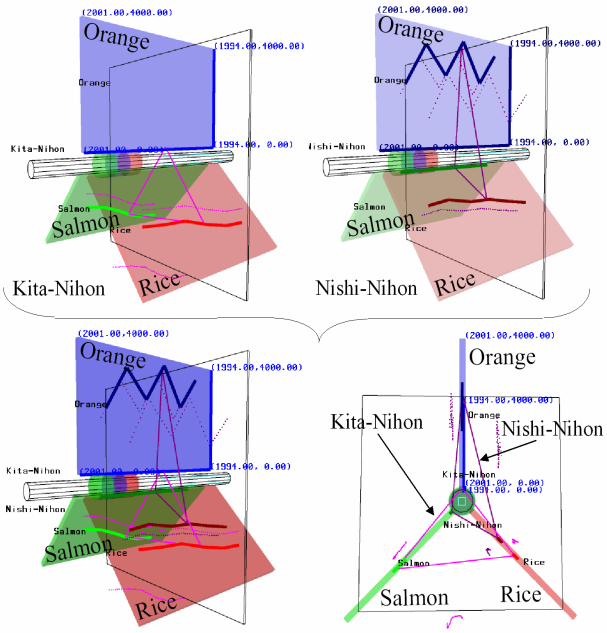

Fig. 4. Screen snapshot of parallel combination of two *Time-tunnels*.

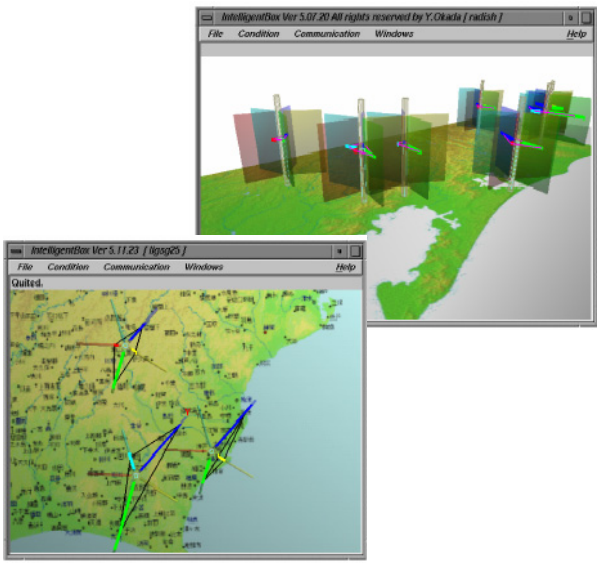

Fig. 5. Screen snapshot of *Time-tunnel*.

combination and the other is hierarchical combination.

The example structure of the parallel combination is shown in Figure 3. Multiple *Time-tunnels* are connected with one arbitrary root *box*. Through the root *box*, operations on the *time-planes* of sibling *Time-tunnels* are synchronized. The user can see the radar chart of each *Time-tunnel* simultaneously. Figure 4 shows a simple but actual example. Two *Time-tunnels* are connected to a root *box*. The *data-wings* of each *Time-tunnel* represent the harvest amounts of "rice", "orange" and "salmon" in a certain year. The *Time-tunnel* shown in the upper left part of Figure 4 visualizes the data set of north Japan. The other shown in the upper right part of Figure 4 visualizes the same kind of data set of west Japan. As shown in the lower part of the figure, by overlapping the two *Time-tunnels*, the user can compare the data sets of two areas of Japan. Figure 5 shows

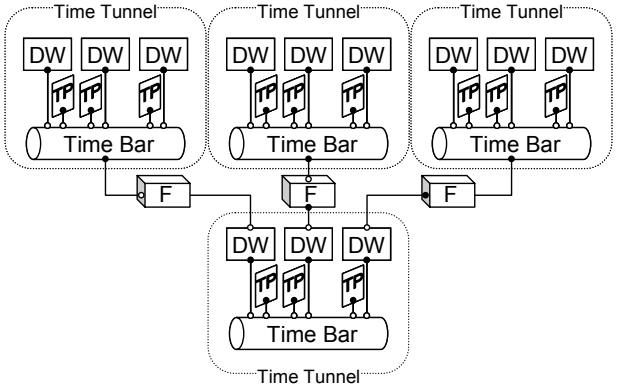

Fig. 6. Hierarchical combination of *Time-tunnels*.

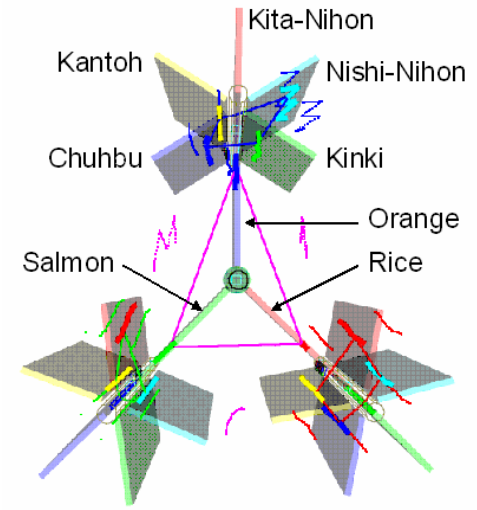

Fig. 7. Screen snapshot of hierarchical combination of one parent and three child *Time-tunnels*.

another example of the parallel combination usage. In this example, there are many *Time-tunnels* each of which is functionally connected to a root *box* that represents a map of Tokai area of Japan and located at a different city/town. Each *Time-tunnel* shows the transitions of "rice price", "the number of laborers" and "the number of horses collected by the lord of a manor" in 19th century corresponding to its located city/town. By sliding the *time-planes* of the *Time-tunnels* simultaneously, the user can see the change of each data in the whole Tokai area.

The second type of combination is the hierarchical combination of *Time-tunnels*. Its example composite structure is shown in Figure 6. Each of the child *Time-tunnels* is attached to a different *data-wing* of its parent *Time-tunnel*. Figure 7 shows the snapshot of one actual example of the hierarchical combination usage. Each child *Time-tunnel* visualizes the harvest amount of one of "rice", "orange" and "salmon" for five different areas in Japan on its five *data-wings*. In each child *Time-tunnel*, the sum of data, i.e., one of "rice", "orange", or "salmon", of all five areas is automatically calculated by a function *box* indicated by a symbol 'F' in Figure 6 and it will be sent to the corresponding *data-wing* of the parent *Time-tunnel*. As a result, the user can see three time-series sum values for the harvest amounts, "rice", "orange" and "salmon", on the three data-wings of the parent *Time-tunnel*.

Besides the above two combinational usages, many other combinations are possible using other components, *boxes*. For example, it is possible to display multiple charts at the same time on different views by using already existing software component called *CameraBox*[2].

4. Concluding Remarks

In this paper, we introduced a 3D visualization tool called *Time-tunnel*. *Time-tunnel* visualizes any number of time-series numerical data records as individual charts in a virtual 3D space. More than two different charts are put overlapped together to compare them in order to recognize the similarity or the difference among them. Moreover, a radar chart among those data records at any particular time point and correlation scattered points between any two adjacent records are simultaneously displayed to look at their similarity or correlation. With *Time-tunnel*, the user can analyze data through interactive manipulations on a computer screen.

Since *Time-tunnel* is realized as the composite component of *IntelligentBox*, many combinational usages of *Time-tunnel* are possible. In this paper, we proposed two typical combinational usages, i.e., the parallel combination and the hierarchical combination of *Time-tunnels*. By showing simple but actual examples, we described the availability of such combinational usages of *Time-tunnel*.

As future works, we have to evaluate the usefulness of *Time-tunnel* by consulting many users who can exploit it for their analysis of real multiple numerical data or multidimensional data. We also have to find practical usage of *Time-tunnel* as a multimedia presentation tool because *Time-tunnel* has such aspects. In fact, the composite components shown in Figure 4 and Figure 7 were composed manually by the user. Since this is not convenient, we are also trying to develop the functionality that automatically generates such composite components.

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