IntelligentBox Based Interactive 3D Information Visualization Frameworks for Comparison and Exploration: An Overview

Masahiko Itoh

Institute of Industrial Science, University of Tokyo
`imash@tkl.iis.u-tokyo.ac.jp`

Abstract. This paper introduces an overview of IntelligentBox based interactive 3D visualization frameworks for exploring large information space, and shows example applications using such frameworks. We first introduce WorldMirror and WorldBottle that embed 3D information spaces as 3D components into a 3D environment to navigate information in the 3D space. Second, we introduce spreadsheet based coordinated multiple 3D information visualization framework. Third, we show TimeSlices that are 2D planes in the 3D space for exploring changes in time sequential data with structures.

Keywords: Visualization, CMV, 3D system, Interactive System, IntelligentBox, TimeSlice.

1 Introduction

Explorative information visualization systems have been considered as an important layer of researches in the era of Big Data to find out new knowledge from huge information space. Information visualization is not static representation of information such as InfoGraphics. Information visualization requires interactive seeking processes to navigate new knowledge, such processes are mentioned as Shneiderman's mantra [8]; "Overview first, zoom and filter, details-on-demand".

IntelligentBox [10] is a component-based visual software development system for interactive 3D graphics applications. Each 3D component in IntelligentBox environment called box is connected each other through slot connection to construct 3D applications such as 3D visualization systems. The constructed 3D applications as composite boxes are editable and reusable. Users can copy composite boxes, and change attribute values for comparing data. IntelligentBox therefore match for base infrastructure for constructing interactive visualization system in a 3D environment.

Much work related to IntelligentBox based information visualization researches have been introduced [12,3,15,11] after Ohigashi et al. have introduced first system at WISS 1997 (Japanese domestic workshop on interactive systems and software).
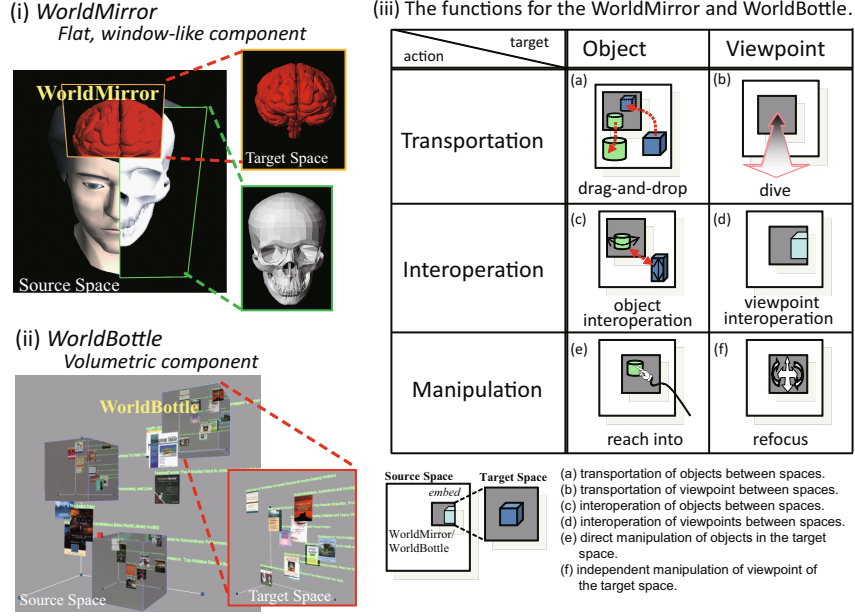
(i) *WorldMirror*
Flat, window-like component

(ii) *WorldBottle*
Volumetric component

(iii) The functions for the WorldMirror and WorldBottle.

action \ target	Object	Viewpoint
Transportation	(a) drag-and-drop	(b) dive
Interoperation	(c) object interoperation	(d) viewpoint interoperation
Manipulation	(e) reach into	(f) refocus

(a) transportation of objects between spaces.
(b) transportation of viewpoint between spaces.
(c) interoperation of objects between spaces.
(d) interoperation of viewpoints between spaces.
(e) direct manipulation of objects in the target space.
(f) independent manipulation of viewpoint of the target space.

Fig. 1. The WorldMirror, the WorldBottle, and their functions

This paper introduces our previous work on coordinated multiple visualization frameworks for exploring information in the large information space based on the IntelligentBox architecture. Section 2 presents WorldMirror and World-Bottle that embed 3D information spaces as 3D components into a 3D space to navigate information in the 3D space through doors in 3D space. We next introduce spreadsheet based 3D information visualization framework to compare and explore various types of information and representations in Section 3. We then provide TimeSlice that is a visualization component for exploring temporal changes in structures and values such as changes in hyperlink structures on the Web in Section 4.

2 WorldMirror and WorldBottle

We have introduces two types of visual components; a flat, window-like component WorldMirror (Fig. 1 (i)) and a volumetric, arbitrary shape WorldBottle (Fig. 1 (ii)) [1]. They enable users to construct a hyperlinked space in the 3D virtual environment, and to navigate through such a 3D hyperlinked space. By using WorldMirror/Bottle, any arbitrary 3D space can be embedded into any arbitrary 3D component which renders the space on their surface, so that users can look into the contents of other spaces from their current working space, and enter them. They also allow users to manipulate contents in embedded spaces from their current space, and to move an object from an embedded space to
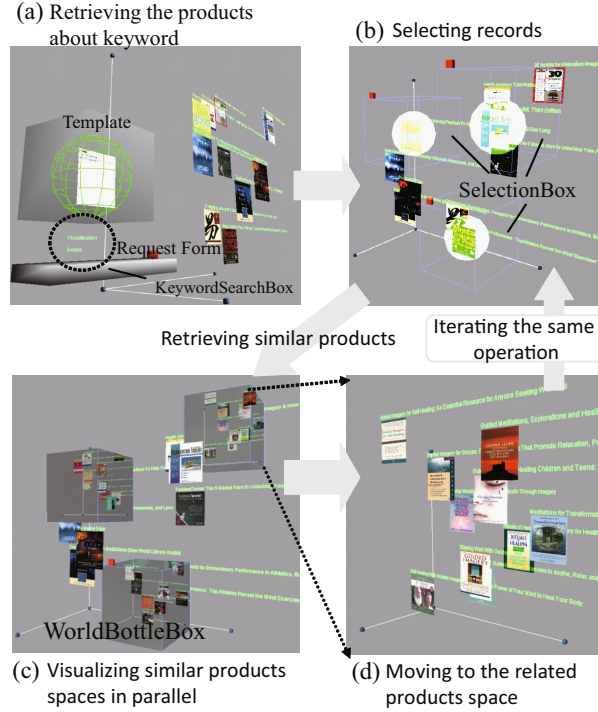
(a) Retrieving the products about keyword

Template

Request Form

KeywordSearchBox

(b) Selecting records

SelectionBox

Retrieving similar products

Iterating the same operation

WorldBottleBox

(c) Visualizing similar products spaces in parallel

(d) Moving to the related products space

Fig. 2. Successive navigation through WorldBottle using the Similar Products Search

the current working space, vice versa. To construct the navigatable structure through a large information space, WorldMirror and WorldBottle provide the functions described in Fig. 1 (iii).

Example in Fig. 2 shows an application for exploring similar products in a 3D environment using the Amazon Web service (AWS).First, the user can examine products from keywords using the KeywordSearch. The records retrieved from a KeywordSearch are visualized in the current space (Fig. 2 (a)) using a mechanism described in [3]. If the user is interested in the related products information about a visualized prouct, the user can select a product dynamically and search the related products about the selected product from the SimilaritySearch (Fig. 2 (b)). The records retrieved from the SimilaritySearch are visualized in another space. When the user approaches the selected product, WorldBottles appear, and the user can observe the related products about any selected one from the current space (Fig. 2 (c)). If the user wants to compare related products about several products, the user can select more than one product and visualize in multiple spaces (Fig. 2 (b)(c)). The user can enter the related product space, in which there are many products that the user prefers (Fig. 2 (d)). The user can explore these related products recursively (Fig. 2 (d)-(b)).
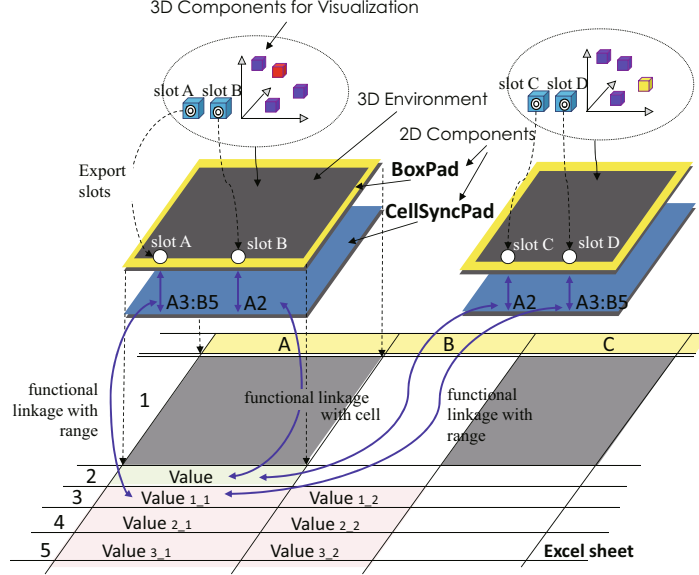
Fig. 3. Overview of architecture for spreadsheet-based coordinated parallel visualization

3 Coordinated Multiple 3D Visualizations on Spreadsheet

We have proposed a spreadsheet-based visualization framework for end-users to generate and modify multiple 3D visualizations of data-sets from various Web resources [2]. Our framework enables users to use various values for different parameters and/or different 3D components in parallel to enable exploratory searches for solutions by making intercomparisons of multiple results.

Our approach enables users to embed 3D visualization environments into spreadsheet cells (Fig. 3). We utilize an Excel spreadsheet environment to define multiple coordinated visualizations. A 3D visualization environment is an IntelligentBox environment itself. We can construct 3D visualizations in this environment. Our approach also allows users to only export the necessary functions of 3D visualization mechanisms into the embedded environments to input and output parameter values to and from spreadsheet cells. By using this facility, users can share the slot values of boxes in different visualization environments in different cells through spreadsheet cells. To define coordination, we provide interactive 2D/3D components and coordination rules that enable users to use operations for coordination such as brushing and linking, retrieving related or detailed information one after another, synchronizing viewpoints between 3D visualizations, and sharing table values between 3D components for visualizations and cells on Excel.
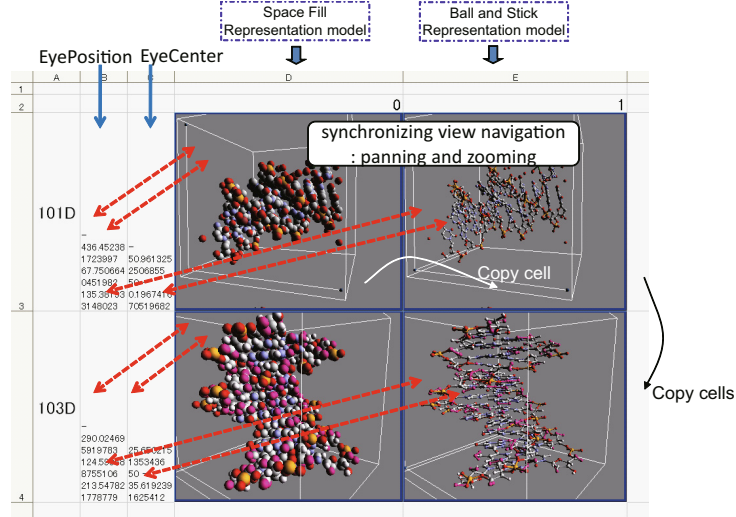
Fig. 4. Multiple visualizations of 3D structure of protein and/or DNA

Fig. 4 shows an example of visualizing 3D structures of protein/DNA using multiple data-sets, visual representations and angles. We can get the 3D structure data-sets for protein and DNA through Web service. In this example, we first input a PDB ID to visualizer components [3] in 3D environments through a cell. We can copy visualizations just through copying the cells to compare various data-sets with different representations. Visualizations of each row can have the different data-sets. We can change the 3D representation of protein structure just by inputting a template ID into the range D1:E1. We can also synchronize angle of view rendering among different cells through sharing parameters.
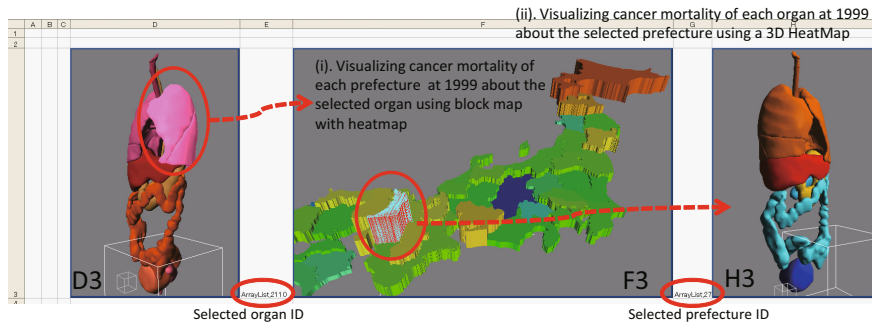

Fig. 5. An example of visualizing cancer mortality of each prefecture and of each organ
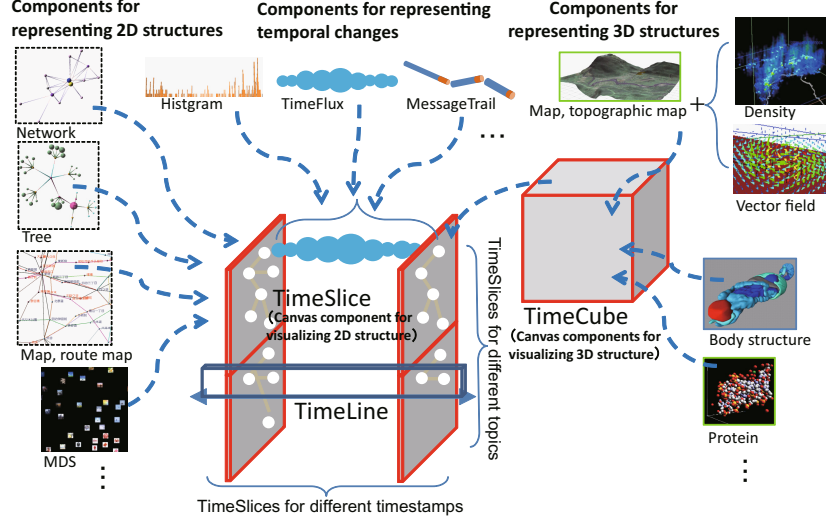
Fig. 6. 3D visualization framework for for temporal changes in structures and values

Fig. 5 shows an example of visualizing the cancer mortality in Japan by prefecture and organ. Cell D3 shows an organ map. Users can select one organ to see the mortality from cancer for the organ they selected. In this example, cell F3 shows the cancer mortality for all prefectures in 1999 for the selected organ using a block map and a HeatMap. These results indicate that Osaka prefecture has the highest rate of mortality from lung cancer. Users can also select one prefecture in cell F3. Cell H3 visualizes the cancer mortality for all organs in 1999 for selected prefectures using the 3D HeatMap. Here, the mortality from liver cancer is higher than that from lung cancer in Osaka prefecture in 1999.

4   TimeSlice

We have introduced visualization framework for temporal changes in 2D/3D structures and values (Fig. 6). In this framework, we can construct 3D visualization applications through combining interactive Timeline component, 2D or 3D canvas components called TimeSlice [7] and TimeCube respectively. 2D canvas component can use components for representing 2D structures such as network, tree, and map. 3D canvas component can use component for representing 3D structures such as map, density, and vector field. Structures on canvas components change along position on the TimeLine. We can also add components for representing changes in values along the timeline such as histogram, and TimeFlux [4]. Moreover, we can copy canvas components to compare different timings and multiple topics.

Fig. 7 shows a system for analyzing temporal changes in the activities and interests of bloggers through a 3D visualization of phrase dependency structures
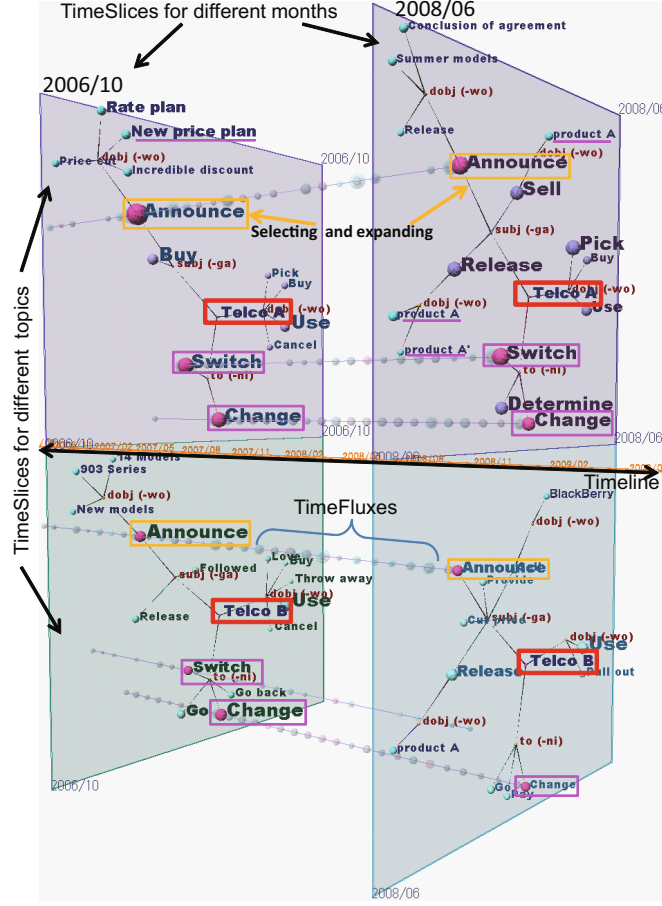
Fig. 7. Comparing Marketing Effect of two Telcos

in sentences [6]. The upper TimeSlice shows a topic for 'Telco A', while the lower one shows a topic for 'Tepco B'[1]. We can recognize events related to 'change/switch to Telco A' are more popular than 'change/switch to Telco B' in most months by observing changes in the structure and frequencies for events. To start exploring possible reasons for such actions and plans, we first find times when events "change/switch to Telco A" are popular, and then observe events around them on the TimeSlice in detail. We can see that there are some peaks in the events 'switch to Telco A' by observing the size of the spheres on the TimeFluxes. We place TimeSlices at the left on the position of timing when the first peak is observed (October 2006), and TimeSlices at the right for the second peak (June 2008). We find that 'Telco A' announced or released something because the size of the 'announce' and 'release' nodes increased. We next expand

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[1] Companies' names have been anonymized.

(a) Visualizing temporal changes in rainfall strength over Taiwan

(b) Visualizing temporal changes in amount of tweets in Tokyo after Earthquake
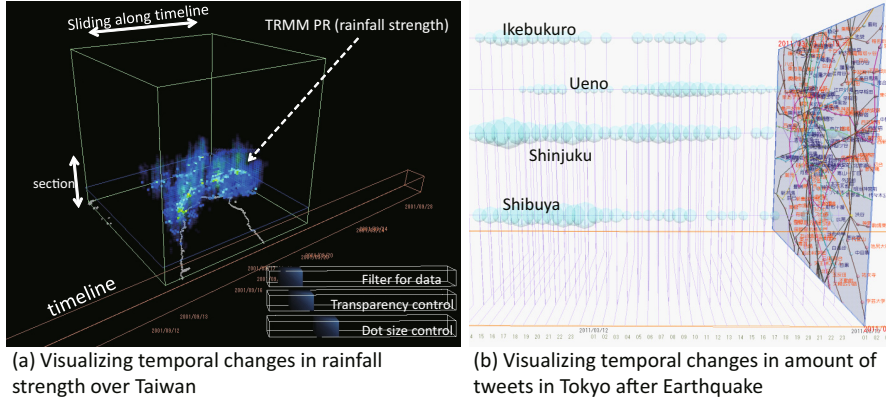
Fig. 8. Example of visualizing temporal changes in values on 3D/2D geographical space

these nodes to find details on announcements and products that were released, and we then find that they announced a 'new price plan' in the first peak, and released 'product A' in the second peak. However, although 'Telco B' also announced new products very frequently, there are few peaks related to events 'switch' for 'Telco B'. These results mean that 'Telco A's' marketing activities had more impact in Japan than those by 'Telco B'.

Fig. 8 shows examples of visualizing temporal changes in values on 3D/2D geographical space. Fig. 8 (a) visualizes temporal changes in rainfall strength over Taiwan around typhoon season in which data is collected through DIAS project[2]. We can recognize rain concentrates along shoreline of Taiwan. Fig. 8 (b) visualizes temporal changes in amount of tweets in Tokyo after Earthquake on March 11, 2011. We can recognize that many people tweets whole through night around main stations in Tokyo because transportation systems stopped. We can also find out each station such as Shibuya, Shinjuku, Ueno, and Ikebukuro shows different trends in frequencies of tweets.

We have proposed an interactive visualization system to extract networks of historical figures from historical data and to show time-varying changes in their relationships [5] (Fig. 9). We use red for clusters related to "adversarial relationship" or "battle", blue for clusters related to friendship, green for others, and gray for keywords that are not categorized in any clusters. Fig. 9 shows temporal changes in characteristics of selected relationships between historical figures[3]. Fig. 9 (b) shows red edges between TOKUGAWA Ieyasu and TAKEDA Katsuyori. These represent their relationships in continual battles. Fig. 9 (c) shows changes in the relationship between ODA Nobunaga and UESUGI Kenshin for each year. Fig. 9 (d) visualizes complex relationships between Nobunaga and ASHIKAGA Yoshiaki.

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[2] http://www.editoria.u-tokyo.ac.jp/dias/index.html
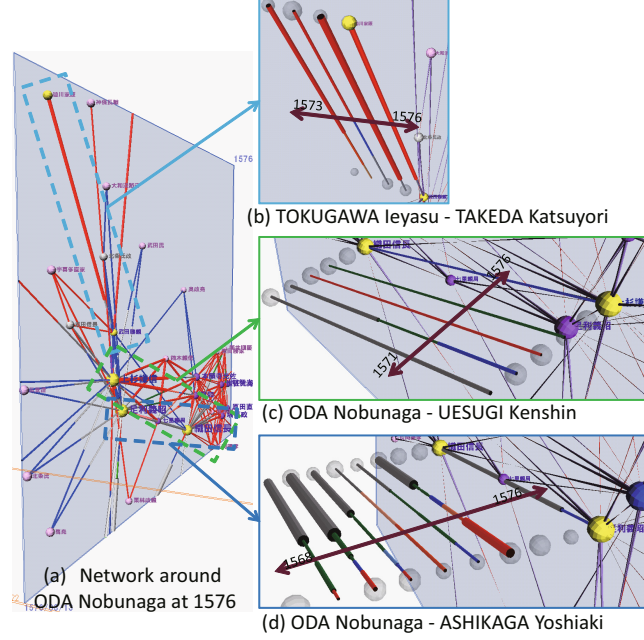[3] They are powerful territorial lords in pre-modern Japan.

Fig. 9. Changes in relationships between historical figures around ODA Nobunaga

5   Conclusion

We have introduced our interactive information visualization framework on 3D focusing on comparison and exploration using coordinated multiple views techniques based on the IntelligentBox architecture. The frameworks introduced in this paper are generic frameworks. They can derive for many explorative applications. WorldMirror and WorldBottle shown in Section 2 are applied to various types researches on exploring information spaces [13,14]. TimeSlices are also applied to various kinds of information with temporal changes such as relationships between peoples in social media [4] or historical data [5], extracted activities in social media by using NLP techniques [6], and hyperlink structures on the Web [7].

The challenges left are applying these frameworks to big data; how to visualize overview of absolutely huge amount of data, and seamlessly move on to zoom and filter mentioned in Shneiderman's mantra, or how to combine other analysis processes using such as machine learning to show important part of dataset mentioned in Keim's visual analytics mantra [9]; "Analyze first - show the important - zoom, filter and analyses further - details on demand.".

References

1. Itoh, M., Ohigashi, M., Tanaka, Y.: WorldMirror and WorldBottle: Components for Interaction between Multiple Spaces in a 3D Virtual Environment. In: Proc. IV 2006, pp. 53–61 (2006)
2. Itoh, M., Tanaka, Y.: A Framework for Constructing Coordinated Multiple 3D Visualizations on Excel. In: Proc. IV 2009, pp. 162–170 (2009)
3. Itoh, M., Tanaka, Y.: 3D Component-Based Visualization Framework for Generating Simple 3D Applications Using Web Services. In: Proc of WI 2006, pp. 823–830 (2006)
4. Itoh, M.: 3D Techniques for Visualizing Users' Activities on Microblogs. In: Proc of the IET International Conference on Frontier Computing - Theory, Technologies and Applications, pp. 384–389 (2010)
5. Itoh, M., Akaishi, M.: Visualization for Changes in Relationships between Historical Figures in Chronicles. In: Proc. of IV 2012, pp. 283–290 (2012)
6. Itoh, M., Yoshinaga, N., Toyoda, M., Kitsuregawa, M.: Analysis and Visualization of Temporal Changes in Bloggers' Activities and Interests. In: Proc. PVis 2012, pp. 57–64 (2012)
7. Itoh, M., Toyoda, M., Kitsuregawa, M.: An Interactive Framework for Visualizing Time-series of Web Graphs in a 3D Environment. In: Proc. IV 2010, pp. 54–60 (2010)
8. Shneiderman, B.: The Eyes Have It: A Task by Data Type Taxonomy for Information Visualizations. In: Proc. of VL 1996, pp. 336–343 (1996)
9. Keim, D.: Scaling Visual Analytics to Very Large Data Sets. In: Workshop on Visual Analytics, Darmstadt (2005)
10. Okada, Y., Tanaka, Y.: IntelligentBox: A Constructive Visual Software Development System for Interactive 3D Graphic Applications. In: Proc. of CA 1995, pp. 114–125 (1994)
11. Notsu, H., Okada, Y., Akaishi, M., Niijima, K.: Time-tunnel: Visual Analysis Tool for Time-series Numerical data and its Extension toward Parallel Coordinates. In: Proc. CGIV 2005, pp. 167–172 (2005)
12. Ohigashi, M., Tanaka, Y.: A Framework for the Virtual Reification of Database Records. Trans. of Information Processing Society of Japan 42(sig1(20010115)), 80–91 (2001)
13. Ohigashi, M., Tanaka, Y.: 3D Space Framework for the Multi-facet Accessing of Database Records. In: Grieser, G., Tanaka, Y. (eds.) Dagstuhl Seminar 2004. LNCS (LNAI), vol. 3359, pp. 142–158. Springer, Heidelberg (2005)
14. Akaishi, M., Ohigashi, M., Spyratos, N., Tanaka, Y.: Information Access Space Framework over Contextualized Information Base. In: Proc. IV 2003, pp. 414–420 (2003)
15. Sugibuchi, T., Tanaka, Y.: Integrated Framework for the Visualization of Relational Databases and Related Web Content. In: Proc. of the 2003 Joint Conference of the Fourth International Conference, pp. 197–201 (2003)