Interactive Space-Time Planes for Document Visualization

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Abstract

This paper describes constructs called interactive space-time planes along with an application called the SpaceTime Browser for visualizing and retrieving documents. A 3D visualization with 2D planar maps and a time axis is employed. Users can slide the planes along the time axis to choose time intervals, and select regions on the planes. Regions are highlighted when there are documents with matching space-time attributes, and the documents are retrieved and displayed in an adjoining workspace. Two examples are illustrated: (1) organizing travel photos, (2) managing documents created by room location-aware devices in a building.

1. Introduction

Document collections can be visualized and browsed through space and time attributes associated with the documents. By making use of these natural attributes, users are freed from having to deal with filenames and directories that are more suitable for computers than people. The space or time attribute may be associated with a document's content or context. Examples of each type are: the address of a house for sale in a real estate listing (space-content), the date of an event in a news report (time-content), the room where notes were taken (space-context), and the revision time of a paper draft (time-context).

Graphical user interfaces have been designed for handling documents that focus either on location (see [7]) or time (see [4], [6]). A unified visualization of both the space and time dimensions can be achieved with "space-time diagrams", which are commonly used to illustrate physical phenomena and examples of these may be found in popular science books (e.g. [5]).

In this paper, we present a design of interactive and dynamic space-time diagrams for information visualization on computers, which we call interactive space-time planes. These are integrated into an application called the SpaceTime Browser. We illustrate these concepts with two concrete examples: organizing travel photos (Fig. 1), and managing documents created by room location-aware devices in a building (Fig. 2).

2. Interactive Space-Time Planes

Our design of interactive space-time planes employs a 3D visualization with one dimension (the vertical *z*-axis) for time and the other two dimensions for space (see left part of Fig. 1). Spatial information is represented by a rectangular plane that contains an image with active regions; e.g. a map of a geographical area (Fig. 1) or a floor plan of a building (Fig. 2). Regions are labeled with tooltips that pop up when the cursor hovers over the region. A user can select a region (e.g. an island in Fig. 1 or a room in Fig. 2) on a space-time plane by clicking on it. Zooming in or out of a region is performed through a context menu brought up with a right-click on the region.

Abstract geometric regions may also be used in the image of a space-time plane to represent virtual places or to consolidate remote sites. An image and its regions are specified in 2D (with the HTML image map format) and are automatically transformed into the 3D visualization.

A handle where the plane meets the time axis allows the user to slide the plane up and down along the axis to choose a time point for browsing. Two sliders are provided for selecting how much time to include before and after the chosen time point (Fig. 2). The user can set the granularity of the time axis to days, months, or years. The timeline is telescopic: a segment can be expanded/contracted by right-clicking on it and dragging down/up.

If there are documents whose time attributes fall into the selected time interval, the regions on the space-time plane that match the space attributes of these documents are highlighted in color (Fig. 1). Selecting highlighted regions retrieves the documents satisfying the space-time constraints; these documents are displayed in a separate workspace (Fig. 1).

3. Space-Time Browser

The SpaceTime Browser is an application that has space-time planes integrated with a document workspace

(Fig. 1). It pulls data from information repositories containing documents tagged with key space-time attributes.

A region that has been selected has a line connecting it to the workspace's left edge. Displayed in the workspace are the documents whose space and time attributes belong inside the selected regions and time intervals. Each document is viewed in its own component window in the workspace. The border of a document component is colored to reflect information about the time and space attributes of the document. The vertical border edges, which are parallel to the time axis, are colored to indicate whether the document's time attribute is before (shade of red) or after (shade of blue) the time coordinate of the space-time plane. The horizontal border edges are colored the same color as the region on space-time plane containing the document's space attribute.

Documents are faded to indicate how relevant their space and time attributes are to the selected regions and time interval. One factor affecting relevance comes from sensor uncertainty when automatic location detection systems are used (see [2]). A relevance score incorporates location uncertainty along with how far the time attribute is from the time coordinate of the plane. Normalizing the relevance score between 0.0 and 1.0 yields the alpha value for fading in the visualization.

Multiple planes can represent several floors of a building (Fig. 2), or two copies of a space-time plane can show the same regions at different times. A user can add a plane by placing the cursor at the desired position and choosing the Add Plane command from a context menu that pops up with a right mouse click. A user can move documents around different planes. A document can be dragged from the workspace into the desired region on a plane. An example of this is moving a meeting agenda to a conference room for next week's meeting.

4. Conclusion and Future Work

We described interactive space-time planes and an application for browsing and visualizing document collections. We believe that people tend to find it easier to identify documents with time and places than with made-up filenames and hierarchical directories. We plan to deploy the SpaceTime Browser and learn more about the effectiveness of this technique, beginning with document collections that are generated and captured in different rooms and times (e.g. see [1] [2], [3]). There are many other related domains that can be explored in conjunction with location technologies such as GPS.

5. References

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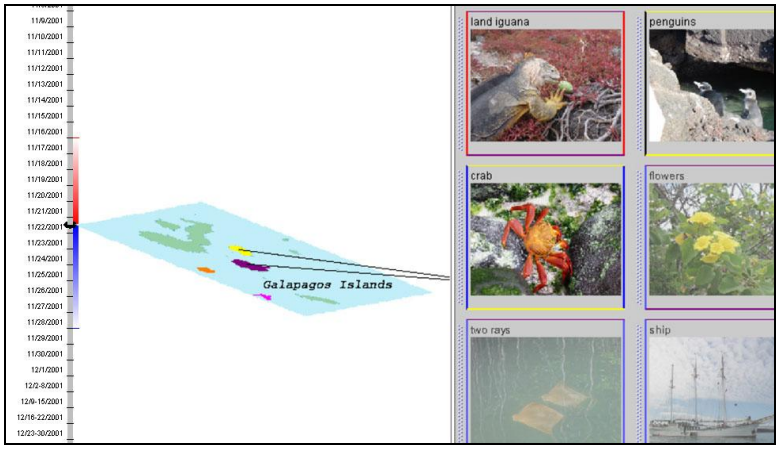

Figure 1. Partial screenshot of the SpaceTime Browser. A space-time plane with an image map of the Galapagos Islands is integrated with a workspace on the right for viewing digital photos.

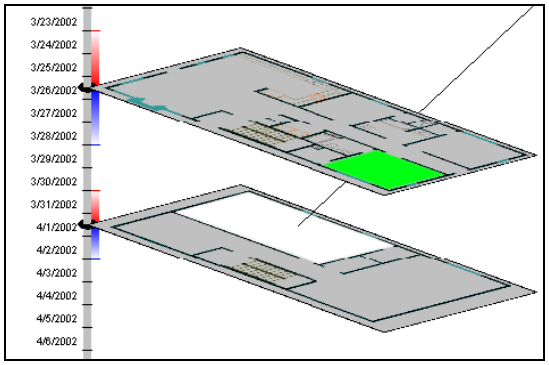

Figure 2. Detail of multiple space-time planes and time sliders. The image maps show two floors of Georgia Tech's Aware Home building with highlighted rooms.