

# Interactive Space-Time Maps for Document Visualization

Patrick Chiu  
FX Palo Alto Laboratory  
3400 Hillview Ave., Bldg. 4  
Palo Alto, CA 94304 USA  
chiu@fxpal.com

Khai N. Truong  
College of Computing & GVU Center  
Georgia Institute of Technology  
Atlanta, GA 30332-0280 USA  
khai@cc.gatech.edu

## Abstract

*This work presents constructs called interactive space-time maps along with an application called the SpaceTime Browser for visualizing and retrieving documents. A 3D visualization with 2D planar maps and a time line is employed. Users can select regions on the maps and choose precise time intervals by sliding the maps along the telescopic time line. Regions are highlighted to indicate the presence of documents with matching space-time attributes, and documents are retrieved and displayed in an adjoining workspace. We provide two examples: (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 picture 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 maps*. 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 Maps

Our design of interactive space-time maps 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 map 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) by clicking on it with the mouse. Zooming in or out of a region is performed through a context menu brought up by a right-click on the region.

Abstract geometric regions may also be used in the image of a space-time map to represent virtual places or to consolidate remote sites. Data spatialized and reduced to 2D, from simple scatterplots to results of techniques such as multidimensional scaling, provides another source of maps.

The timeline is telescopic: a segment can be expanded/contracted by right-clicking on it and dragging down/up. Granularity levels are given in familiar units of years, months, weeks, days, etc. A handle allows the user to slide a map up and down along the time axis to choose a time point for browsing. Two sliders are provided for selecting how much time to include before and after a chosen time point (Fig. 2).

If there are documents whose time attributes fall into the selected time interval, the regions on the space-time map 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 (see right part of Fig. 1).

## 3. Space-Time Browser

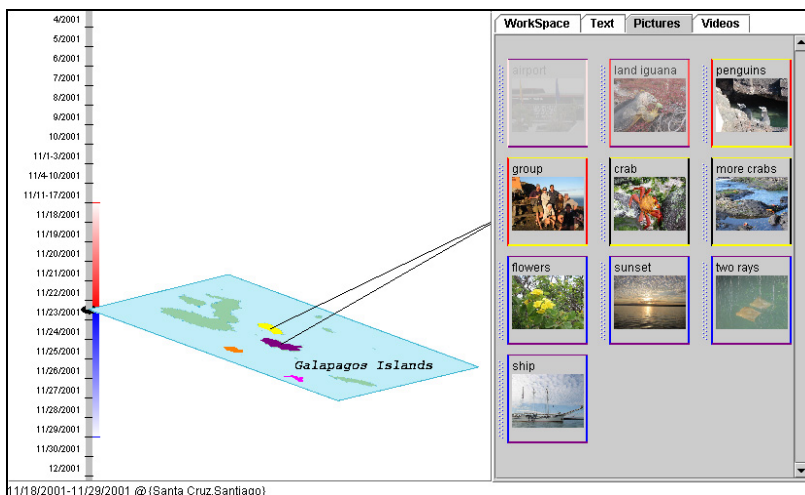
The SpaceTime Browser is an application that has space-time maps integrated with a document workspace

(Fig. 1). It pulls data from information repositories containing documents tagged with key space-time attributes. Documents are retrieved dynamically when the user selects time intervals and regions.

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. A document's border is colored to reflect information about its time and space attributes. Vertical border edges, parallel to the time axis, are colored to indicate whether the document's time attribute is at (black), before (shade of red), or after (shade of blue) the time coordinate of the space-time map. Horizontal border edges are colored with the highlight color of the matching region. See Fig. 1.

Documents are faded to indicate how relevant their space and time attributes are to the selected regions and time intervals. One factor affecting relevance comes from sensor uncertainty when automatic location detection systems are used (see [2]). A relevance score incorporates location uncertainty together with how far the time attribute is from the time coordinate of the map. Normalizing the relevance score between 0.0 and 1.0 yields the alpha value for fading. As shown in Fig. 1, the upper-left photo is noticeably faded.

Multiple maps can represent several floors of a building (Fig. 2), or two copies of a space-time map can show the same regions at different times. Adding a map is performed by activating a context menu at the desired position and choosing the Add Map command. A user can move documents to different maps. A document can be dragged from the workspace to the desired region on a map. An example of this is moving a meeting agenda to a conference room for next week's meeting.



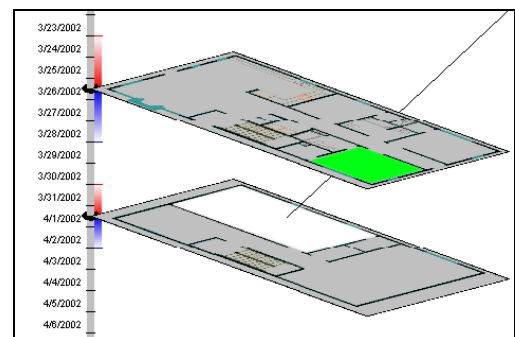
**Figure 1. Screenshot of SpaceTime Browser. A space-time map of the Galapagos Islands is integrated with a workspace on the right for viewing photos and other types of documents.**

## 4. Conclusion and Future Work

We presented interactive space-time maps and the SpaceTime Browser for visualizing and retrieving documents. We believe that people tend to find it easier to identify documents with times and places than with made-up filenames and hierarchical directories. Our plan is to deploy the SpaceTime Browser and learn more about the effectiveness of this technique, beginning with multimedia content created by digital cameras and documents captured in different rooms and times ([1], [2], [3]). As information appliances become ubiquitous and location-aware [7], new techniques such as interactive space-time maps will be helpful to manage the mass of data.

## 5. References

1. Abowd, G., Atkeson, C., Hong, J., Long, S., Kooper, R., and Pinkerton, M. Cyberguide: A mobile context-aware tour guide. *ACM Wireless Networks*, 3 (1997), pp. 421-4333.
2. Castro, P., Chiu, P., Kremenek, T., Muntz, R. A probabilistic room location service for wireless networked environments. *Proceedings of Ubicomp '01*, pp. 18-34.
3. Chiu, P., Kapuskar, A., Reitmeier, S., and Wilcox, L. Room with a rear view: Meeting capture in a multimedia conference room. *IEEE MultiMedia*, 7, 4 (Oct-Dec 2000), 48-54.
4. Freeman, E., Gelernter, D. LifeStreams: A storage model for personal data. *ACM SIGMOD Bulletin*, (Mar 1996), 80-86.
5. Hawking, S. *A Brief History of Time*. 10th anniversary edition (1998). Bantam Doubleday.
6. Rekimoto, J. Time-machine computing: A time-centric approach for the information environment. *Proceedings of UIST '99*, pp.45-54.
7. Want, R. and Schilit, B. (Eds.). Special Issue: Location-Based Computing. *IEEE Computer*, 34, 8 (Aug 2001).



**Figure 2. Detail of multiple space-time maps and time sliders. Two floors of Georgia Tech's Aware Home building are shown with rooms dynamically highlighted.**