Author manuscript, published in Proceedings of the International Working Conference on Advanced Visual Interfaces, pp. 433-436, 2012.
DOI: 10.1145/2254556.2254639

TimeSlice: Interactive Faceted Browsing of Timeline Data

Jian Zhao[1,2] Steven M. Drucker[2] Danyel Fisher[2] Donald Brinkman[2]

[1]Department of Computer Science
University of Toronto
jianzhao@dgp.toronto.edu

[2]Microsoft Research
Redmond
{sdrucker | danyelf | donaldbr}@microsoft.com

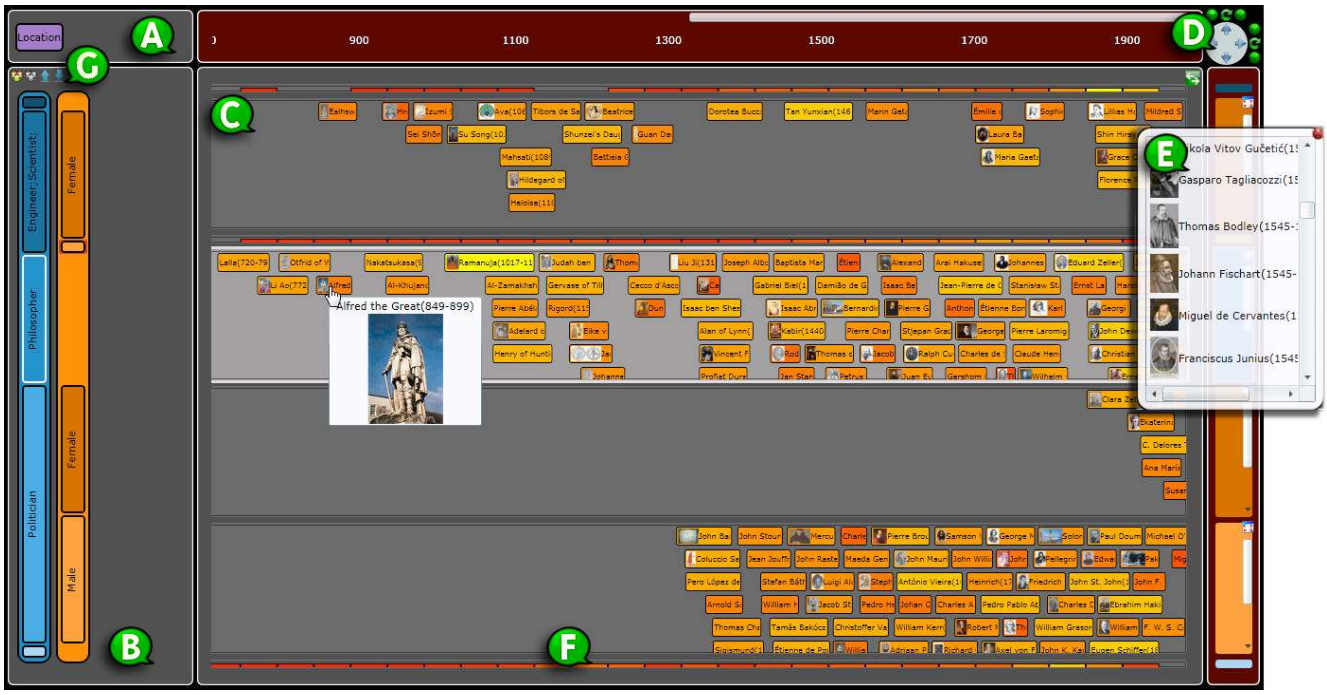

Figure 1. Exploration of lives of famous historical people using TimeSlice. The user is comparing female engineers and scientists, all philosophers, and politicians of each gender. Occupations such as philosophers are popular in early time. But people are actively involved in politics later (about 1300AD) in which females are few and involved even later (about 1900AD). Also, there seems to be fewer female engineers and scientists between 1300AD and 1700AD, which requires further exploration of the history.

ABSTRACT

Temporal events with multiple sets of metadata attributes, i.e., facets, are ubiquitous across different domains. The capabilities of efficiently viewing and comparing events data from various perspectives are critical for revealing relationships, making hypotheses, and discovering patterns. In this paper, we present TimeSlice, an interactive faceted visualization of temporal events, which allows users to easily compare and explore timelines with different attributes on a set of facets. By directly manipulating the filtering tree, a dynamic visual representation of queries and filters in the facet space, users can simultaneously browse the focused timelines and their contexts at different levels of detail, which supports efficient navigation of multi-dimensional events data. Also presented is an initial evaluation of TimeSlice with two datasets - famous deceased people and US daily flight delays.

AVI'12, May 21–25, 2012, Capri Island, Italy.

Categories and Subject Descriptors

H5.2. User Interfaces: *Graphical user interfaces (GUI)*.

General Terms

Design.

Keywords

Faceted Browser, Temporal Events, Timeline Visualization.

1. INTRODUCTION

The analysis of temporal events, common in many domains including science, engineering and the humanities, allows people to discover new trends and patterns. Interactive visualizations have proven efficient in exploring event data in many formats, such as network logs [6], medical records [7], and musical artist history [2]. These temporal events are often multi-dimensional. Faceted browsers enable the viewing of datasets from multiple perspectives, allowing users to create queries to compare events along distinct attributes [5][2]. For example, in Phan et al [6] users working with network logs were able to compare temporal sequences of packets filtered by IP addresses or port numbers. When datasets are novel or users have vague hypotheses, the discovery of serendipitous findings requires multi-foci visualization [10] which simultaneously presents several parts of the data while preserving the context.

To address these needs, we have designed TimeSlice, an interactive faceted browsing tool for temporal events, which provides a flexible approach for constructing, comparing and manipulating multiple queries over faceted timelines. These queries are organized by a dynamic *filtering tree* structure (Figure 1-b) which displays both current focused queries and their contexts (such as queries sharing the same attribute on one facet but different on another). Through multi-foci interaction, the filtering tree allows users to easily browse both the queried timelines and those that are related but have been filtered out, which are important for the Visual Exploration of serendipitous findings [10]. Tree nodes (representing attributes) and tree levels (representing facets) can be manipulated directly, which offers efficient navigation across different perspectives of the data.

In this paper, our contributions include: 1) a novel faceted dataset exploration framework - the filtering tree structure, 2) a prototype application called TimeSlice that interactively visualizes temporal events under the framework, and 3) a light-weight evaluation of the system with two different datasets.

2. RELATED WORK

TimeSlice is a hybrid between a faceted browser and a temporal visualization. Faceted classification systems such as FacetMap [9] and FacetLens [5] present multiple categories in a tiled view and support fast filtering of objects by selecting attributes gradually. DocuBrowse [4] allows users to filter many facets simultaneously and display matched documents. However, these systems except FacetLens [5] do not present a temporal dimension. Continuum [2] and LifeFlow [10] can display events in a single timeline with multi-scale visual encodings. Temporal Summaries [1] introduces align, rank and filter to accentuate the temporal ordering of all the records. But they do not focus on rapid filtering of the data via facets, thus making it difficult to compare multiple timelines with different attributes. For complicated data with hierarchical attributes, FOCUS [8] and LifeLines [7] present the records in rows to enable comparisons along different attributes and sub-attributes. However, the structure is fixed and predefined by the hierarchy, thus dynamic queries based on attributes from multiple facets are not supported. Probably the most similar research to our work is Progressive Multiples [6] which allows users to dynamically query the existing timelines to create new ones and organize them in folders. But unlike TimeSlice, it displays every timeline identically in small multiples, and it only presents timelines that users explicitly query, i.e., those has been filtered out are not shown which may not adequately support discoveries of serendipitous findings.

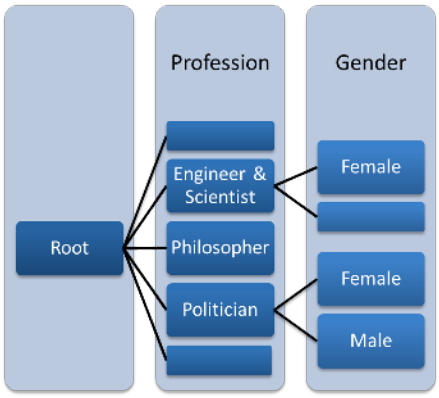

Figure 2. The logical filtering tree of the query structures

3. THE TIMESLICE INTERFACE

The TimeSlice system is a web application developed with the Microsoft Silverlight platform. Its interface contains the following components (Figure 1): a) a facet container showing the available facets that can be added as filters, b) a filtering panel showing the current timeline filtering tree, c) a main window for browsing timelines that are dynamically updated according to the filtering tree, and d) a navigation control that supports multi-scale exploration of the timelines.

The filtering tree represents a group of queries over the dataset which are used to select events to display on the corresponding timelines. Each path from the root node to a leaf node is a single query, which means it is formed by walking along the path while doing filtering operations with the attributes (tree node) on the facets (levels of the tree). For example, the filtering tree UI shown in Figure 1-b has the logical structure shown in Figure 2 which contains seven different queries.

3.1 Interacting with the Filtering Tree

The interface starts with an empty tree in the filtering panel (Figure 1-b) by presenting an overview of the entire dataset in the main window. The user can add a facet to the filtering tree by selecting it from the facet container (Figure 1-a), and the whole dataset are sliced into multiple timelines with items having the corresponding attributes on that facet. As successive facets are added, the height of the filtering tree is increased, which makes it possible to further slice the exploration space. For example, in Figure 3-a, the user has added the orange *gender* and purple *continent* facets. Next the user can choose to selectively subdivide the original timelines with the attributes of each newly added facet, like expanding a tree node, in order to build new queries based on existing ones (Figure 3-b).

A user can expand an attribute node by clicking the blue round "plus" button that appears at the top-left corner of each facet. In Figure 3-a, the user expands the *male* value of the *gender* facet. The *continent* facet expands to show its possible values (Figure 3-b). Similarly, a node can be collapsed by using the "minus" button at the same place. The user then minimizes *Asia* and *Africa* using the blue arrow button (Figure 3-c). Other filtering operations, such as reordering tree nodes, can also be performed with direct manipulation, e.g., the user changes the order of attributes (Figure 3-d) or the order of facets (Figure 3e) using "drag-and-drop".

When an attribute tree node is minimized, as the user did with

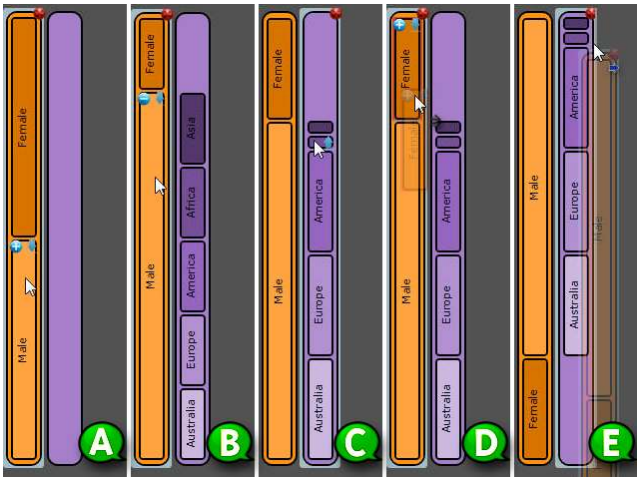

Figure 3. Filtering tree interactions

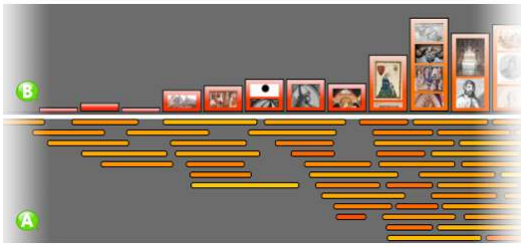

Figure 4. Histogram view and mini-lifespan view

Asia and *Africa*, the system displays a minimized timeline (Figure 1-f). In Figure 1, we implemented the reduced form of timelines as color-coded heat-map bars. These minimized timelines save screen real estate for displaying the timelines of greater interest, while retaining access to the other timelines. The minimized form allows users to both keep an exploration history and easily get back to previous timelines, and make serendipitous discoveries.

In addition to comparisons of filters that have only one attribute on each facet, TimeSlice allows users to group multiple attributes on the same facet thus creating a filtering tree with queries that are constrained by more than one attribute value of specific facets. To do so, the user needs to first select the attribute nodes then press the "group" button in Figure 1-g. For example, in Figure 1 the first maximized timeline groups *engineers* and *scientists* on *profession* facet (blue). This grouping function enables many cross-concept comparisons that traditional interface cannot afford.

3.2 Browsing Timelines

TimeSlice provides basic timeline operations such as zooming and panning the whole timeline canvas in both x and y directions or each individually. These operations are achieved by using the navigation control (Figure 1-d) or directly manipulating the canvas with the mouse. When the content of a timeline requires more vertical space, users can use scrollbars to interact with it individually without scaling the whole canvas vertically. The scale of the whole canvas can also be reset at any time. Though only basic browsing functions are implemented in this prototype, other more advanced multi-scale interfaces (e.g., the fish-eye view [3]) can be easily integrated to facilitate the time dimension navigation.

3.3 Plot Settings, Tooltips and Popups

Once a timeline is created, users can interact with it in several ways. First, users can change the view types of displaying the event items in the timeline. For the famous people dataset, we implemented a histogram view which shows the distribution of people lives (Figure 4-b), a lifespan view which displays each person as a horizontal bar (Figure 1), and a mini-lifespan view to present highly aggregated visualizations (Figure 4-a). Second, when the mouse is over an item in the timeline, a tooltip is displayed with context-based information such as a figure and some text of the person. In addition, when the mouse is inside a timeline, its associated query path in the filtering tree is highlighted. Third, to get more details, the user can click an item and a popup is initiated to view appropriate additional information, such as a list of all the people inside a bin (Figure 1-e) when in the histogram view or a web search results of the selected person when in the lifespan view.

It is important to note that the framework of the TimeSlice filtering tree structure is independent of the representations of events. For event data with less rich information such as network logs where the number of events within a time-span is the important quantity, other types of views can include bar charts, line charts, and bubble charts. Moreover, for timelines with grouped attributes, overlays of multiple plots of different attributes can be displayed for more accurate comparisons. Similarly, the minimized form is independent of the mechanism, and can be selected appropriately to include other types of small multiples.

4. EVALUATION

In order to evaluate whether the design of TimeSlice is helpful for exploring and comparing faceted temporal events, we invited eight volunteers who were generally familiar with novel interfaces and temporal data. All participants were university graduate students. We performed the study using IE 9.0 web browser on a 13.4 inch display (resolution 1280X800 pixels) laptop driven by Windows 7.

Participants were given a brief training on the system's major features, including the facet filtering tree operations, navigation of timelines, and visual representation settings. Then, the participants were asked to address a series of structured questions, and finally they were given unstructured time to explore the system further.

During the structured evaluation period, a dataset of daily US flight delays (1989-1991) was used, in which the facets were airline region (*east*, *mid-west* or *west*), flight elapsed time (*short* or *long*), and arrival delay (*early*, *on time*, *within 1 hour* or *greater than 1 hour*). Thus each timeline showed a series of numbers of delays. Participants were asked to do two types of tasks with this dataset – *identification* tasks and *comparison* tasks. Within each type, the difficulty of tasks were increased gradually in terms of the number of facets or attributes involved and the complexity of operations required, such as grouping of attributes. Examples of identification tasks are: "Find the number of flight delays in *Feb, 1990* for flights that are *long elapsed time* and *early arrival delay*"; and "Identify the *quarter* with the *lowest* number of delays for flights that are *long elapsed time* and in the *east region*". These identification tasks allow the user to get familiar with the system and be prepared for the comparison tasks later. Examples of comparison tasks are: "For the *east region* and *mid-west & west region flights* with *either short or long elapsed time*, which timeline has the *lowest* number of delays overall?", and "Among *early* flights within different *regions*, find the data that you think is most similar to the data of *on-time arrival delay* and *mid-west region*". There were 7 identification tasks and 6 comparison tasks.

During their unstructured (exploratory) time, the people dataset with richer information of the items was used which has facets including gender (*male* or *female*), profession (*artist, writer, scientist, politician* or *philosopher*), and region (*Asia, America, Africa, Australia, Europe,* or *America*). Participants were encouraged to explore the dataset freely using all the functions of the system and they were instructed to "think aloud" so that an observer could monitor how TimeSlice was used to visually explore the data and construct hypotheses.

We then followed with a semi-structured interview to discover participants' general perceptions about the system design and its strengths and weakness. The whole session of study lasted about 40 min for each participant.

5. RESULTS AND DISCUSSION

Participants were able to get familiar with the system quickly; both the filtering tree representations and operations seemed straightforward to users. Each identification task or comparison task was accurately completed in less than a minute. On average, participants spent a little longer on tasks regarding to the number of delays in a specific time period. This may be because users had

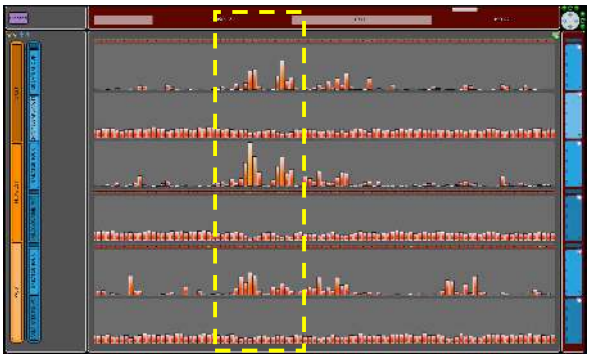

Figure 5. User is exploring US daily flight delay data.

to zoom and pan the timelines to find particular data points. Participants sometimes relied on the order of facets stated in the questions. After completing some of the tasks, they realized that adding facets to the filtering tree in another order would reduce a lot of clicking operations as three participants made comments about: "*I should do the facet reordering first*". Particularly, in one task a participant discovered that for busy seasons like Christmas time there were much larger numbers of flight delays for *greater than 1 hour* compared to the sum of all other attributes on the facet *arrival delay* across all three regions (parts in the yellow box in Figure 5) and especially in Dec. 1990 the delays of the *mid-west* region were extremely high (the third timeline in Figure 5).

During the unstructured time, we found that users were able to make some creative comparisons. For example, one compared *writers & artists* versus *scientists & engineers* from different *continents*, since people of the grouped professions did jobs in similar ways – subjectively or objectively. He found that these two classes of people had similar trends in time – the overall lives distributions in *Europe* were longer and started earlier whereas those in *America* were shorter and started later. A participant identified that there was a burst of the number of *artists* around 1900AD. By further exploring the data, he found that most of them were *male American artists*. As for the visual representation aspects of the people dataset, six participants thought the lifespan views were very attractive. But one participant mentioned it might introduce bias by putting bars of unrelated people together.

Overall, all participants considered that the multi-foci and multi-scale visualization of timelines with different attributes in TimeSlice made comparisons very convenient. One commented: "*I really like to open up an attribute and you get all the related queries along the way of drilling down into the data*" and another commented "*You don't need to make tons of similar queries and add the results one by one for comparison*". They also found attribute groupings were important for creating relative complicated queries. One participant said "*It would be better to have other types of set operations in addition to this union operation*". Users especially liked the direct manipulations of the filtering tree which makes the operations "*obvious and simple*". All the participants thought the TimeSlice interface was aesthetically pleasing and the animations were intuitive.

We also identified several usability issues. The first one is the labeling of the time-axis. We only have tick marks on top of the main window, which makes it difficult to identify a data point at a specific timestamp for timelines aligned at the bottom. One participant suggested adding a vertical line that followed the mouse cursor across the main window and showing the values of data points passing the line with tooltips. Second, participants complained that once the timeline canvas was vertically zoomed, they lost track of the associated queries although the corresponding nodes in the filtering tree were highlighted - "*Probably zooming the filtering tree along with timelines is better*". Third, participants found the current side-by-side layout of timeline comparison was not adequate for detailed comparisons of values of data points, thus other plot layouts such as overlaying of timelines should be supported. Fourth, participants were "lazy" in minimizing timelines unless it was necessary and they said it required too many clicks to leave only the wanted timelines maximized. Therefore some common operations should be provided such as expanding an attribute node with only the selected sub-timelines maximized.

6. CONCLUSIONS AND FUTURE WORK

We have presented TimeSlice, an interactive visualization system for faceted temporal events data. TimeSlice allows users to easily make comparisons of timelines with different attributes via multi-foci interactions and direct manipulations on a dynamic filtering tree. A light-weight evaluation with two datasets indicated that the tool is very useful and efficient for comparing multiple timelines and navigating within the facet space, though a few interactions with the controls should be improved.

In the future, we would like to extend our faceted browsing framework, the filtering tree, to more general faceted datasets such as data items with different sets of facets. For example, if we add history events to the people dataset, how to visualize new items not having the gender facet. We are also interested in testing this framework on rich media data and more complicated temporal events such as hierarchical events. In addition, we aim to integrate other multi-scale exploration techniques for timelines to support efficient comparisons across different timespans. We will continue working with our users to progressively improve the interface design with new functionalities.

7. REFERENCES

[1] J. Allan , R. Gupta , and V. Khandelwal. Temporal Summaries: Supporting Temporal Categorical Searching, Aggregation and Comparison. In *IEEE TVCG,* 15(6), 1049-1056, 2009.

[2] P. André, M. L. Wilson, A. Russell, D. A. Smith, A. Owens, and m.c. schraefel. Continuum: designing timelines for hierarchies, relationships and scale. In *Proc. of the ACM UIST symposium*, 101-110, 2007.

[3] G. W. Furnas. Generalized fisheye views. In *Proc. of the ACM SIGCHI conference*, 16-23, 1986.

[4] A. Girgensohn, F. Shipman, F. Chen, and L. Wilcox. DocuBrowse: faceted searching, browsing, and recommendations in an enterprise context. In *Proc. of the IUI international conference*, 189-198, 2010.

[5] B. Lee, G. Smith, G. G. Robertson, M. Czerwinski, and D. S. Tan. FacetLens: exposing trends and relationships to support sensemaking within faceted datasets. In *Proc. of the ACM SIGCHI conference*, 1293-1302, 2009.

[6] D. Phan, A. Paepcke, and T. Winograd. Progressive multiples for communication-minded visualization. In *Proc. of Graphics Interface*, 225-232, 2007.

[7] C. Plaisant, B. Milash, A. Rose, S. Widoff, and B. Shneiderman. LifeLines: visualizing personal histories. In *Proc. of the ACM SIGCHI conference*, 221-227, 1996.

[8] M. Spenke , C. Beilken , and T. Berlage. FOCUS: The Interactive Table for Product Comparison and Selection, 1996.

[9] G. Smith, M. Czerwinski, B. Meyers, D. Robbins, G. Robertson, and D. S. Tan. FacetMap: A Scalable Search and Browse Visualization. In *IEEE TVCG*, 12(5), 797-804, 2006.

[10] K. Wongsuphasawat, J. A. G. Gómez, C. Plaisant, T. D. Wang, M. Taieb-Maimon, and B. Shneiderman. LifeFlow: visualizing an overview of event sequences. In *Proc. of the ACM SIGCHI conference*, 1747-1756, 2011.

[11] J. Zhao, F. Chevalier, and R. Balakrishnan. KronoMiner: using multi-foci navigation for the visual exploration of time-series data. In *Proc. of the ACM SIGCHI conference*, 1737-1746, 2011.