Interactive Exploration of Geospatial Network Visualization

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ABSTRACT

This paper presents a tabletop visualization of relations between geo-positioned locations. We created an interactive data display, which enables users to visually explore the geospatial network of actors. The easy-to-use multitouch interactions, and the size of the interactive surface invite users to explore the visualization in semi-public spaces.

We describe the implemented prototype for a case study on scientific collaborations between institutions. User studies we conducted at conference demonstrations provide evidence of the prototype usability and usefulness, and its support for understanding the geospatial distribution and connectivity in a network of researchers.

KEYWORDS: Geo-visualization, multi-touch, interactive maps, information aesthetics.

INDEX TERMS: H.5.2 [User Interfaces]: Interaction styles, H.5.1 [Multimedia Information Systems]: Hypertext navigation and maps

1 INTRODUCTION

Geovisualization provides tools for visual exploration of geospatial data, and supports "visually-enabled information retrieval" [5]. This paper describes a prototype, whose main purpose is to enable the interactive exploration of a geospatial network.

The plain display of geo-positioned objects on a map helps users to see real-world clusters in the visualized data set. The geographic distribution of the data, as well as the visual encoding of data values allows users to detect density patterns. Connections between nodes are based on the semantic relation between objects. Our prototype visualizes bi-directional relations based on a shared data value.

Visual and interface design were guided by principles of information aesthetics, aiming at unifying accurate data representation with easy-to-use interactivity. It has been shown that data representations that are perceived as aesthetic lead to higher acceptance and lower abandonment rates [1]. The aimed-for simplicity of visualization and interaction, and the use of a large tabletop display, invites users to engage in discussions on location.

2 CASE STUDIES

We applied our geospatial network visualization in two case studies with distinct data sets: The publication data of the EC-TEL (2006-2010), and Hypertext (1989-2011) conferences.

There has been a vast amount of research in the areas of bibliometry to extract and specify the metrics of scientific publication and citation networks. Several approaches to visualize these networks have been reported on (e.g. [2], [6]). The objective of our case study is not to investigate individuals and their personal co-authorship networks, but rather to enable analyzing the connection network of their affiliations. More specifically, our aim is to direct attention to the spatial relations, in order to enable users to visually explore their scientific neighborhood. For this purpose, we created an interactive prototype with an emphasis on collaborations between universities and research centers.

The inter-institutional relationships are based on co-author data, as "co-authorship seems to reflect research collaboration between institutions, regions, and countries in an adequate manner" [3]. For the case studies, we harvested the data directly from the publishers of conference proceedings. We stored every publication, and cleaned, aggregated, and geo-coded the affiliation data.

3 INTERACTIVE PROTOTYPE

The geo-visualization is shown on a interactive tabletop with multitouch capabilities. With the large interactive surface, the user views and manipulates data on a collaboratively created and used information space. In the case study we visualize the number of publications for each institution, and the collaborations between the institutions.

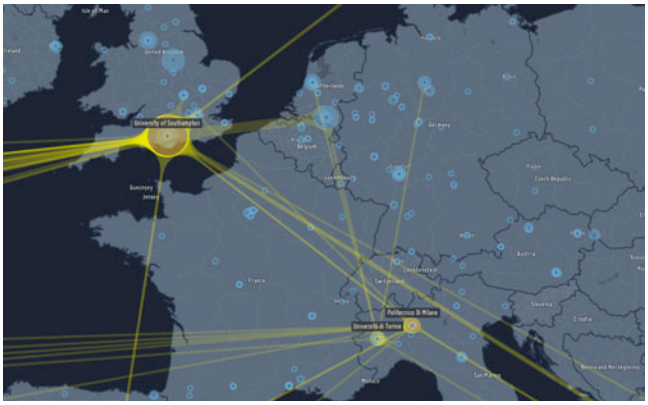

Figure 1. Selected (yellow) and non-selected (blue) institutions.

3.1 Interactions & Visualizations

Our application display a world map, with the institutions shown as markers. The map can be navigated freely, while place markers can be selected to get background information on publication output as well as their relations to other institutions.

Users are able to select the region they are interested in by panning and zooming the map through slide and pinch finger gestures. Cartographic information is provided as map tiles by TileMill[3], which allowed us to customize the map in order to create a unified visualization design.

Institutions are represented by circle markers at their geo-location. The size of a circle indicates the overall number of

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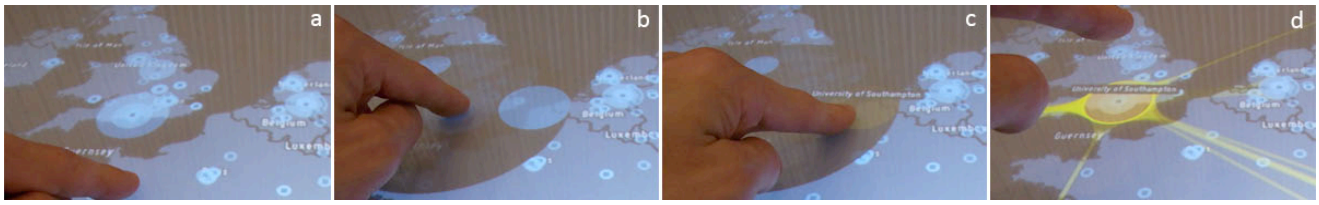

Figure 2. Selecting an institution from a group of near-by markers

papers written by authors from that institution. In order to allow correct data interpretation, and the comparison of different markers, the visual encoding is based on a power law suitable for symbol size discrimination [4].

By tapping on a marker the name of the institution is displayed atop, and relations to other institutions are shown. Besides the label and the connections, selected markers differ visually from non-selected markers, and are displayed in a signal color, in order to support pre-attentive recognition on the map. The layering of the markers are ordered by their sizes, and surrounded by a larger invisible hot area to ease selecting small markers with a finger tap.

3.2 Exploding Menu

Places are all shown at their original geo-location, which results in overlapping markers for institution in close proximity. In contrast to non-geographic layout strategies, where a positioning algorithm may prevent collisions, we opted for a visualization in which the visual scatter shows spatial patterns. However, precise selection of small or overlapping markers is difficult due to the "fat finger problem" [7]. This was also evident in the behavior of the participants in our user study of our first prototype. Thus, we designed *Exploding Menu*, a mechanism to ease the selection of near-by institutions.

In the beginning, multiple overlapping markers are shown on the map (Fig. 2a). When a user touches the marker cluster, a radial menu appears with all the markers evenly laid out on a concentric ring (Fig. 2b). The user can slide (or tap with a second finger) onto the markers, which will be highlighted (Fig. 2c). When the user has chosen one marker and releases his finger, the corresponding institution is selected (Fig. 2d). To select another marker of the same cluster, the interaction pattern has to be repeated. The same mechanism can be used to deselect institutions.

3.3 Connections

Relations between places are visualized by connecting lines between the two markers (Fig. 1). In our case study, a visual connection is shown if authors from two institutions published at least one paper together. The thickness of the connections varies depending on the total number of published papers of both the selected institution and the related institutions. The results of a user study with an earlier prototype lead us to adapt the visualization to map the strength of a connection.

The visual style was chosen for good legibility, while the smooth junctions between the circle marker and the connection aims for an aesthetically pleasing look. The lines connect two institutions transparently, in order to not obstruct the underlying map or markers.

4 Evaluation

We performed two formative user studies with the working prototype visualizing the respective conference data set. The aim was to gather feedback on the intelligibility of the visualization, and the usability of the interactions. The studies were designed as pluralistic usability walkthroughs, each guided by a semi-structured interview. We conducted the user study at a conference setting, in order to report on users executing real tasks, while measuring in-context usefulness of the prototype. We recruited 12 participants, aged 27 to 52 years, from the attendees of the EC-TEL 2010 conference, and nine, aged 23 to 44 years, at the Hypertext 2011 conference. We asked the participants to execute selected tasks, and to answer questions concerning the legibility and understandability of the visualized information. Post-test, we asked subjects to fill out a questionnaire on their opinions and preferences, in order to evaluate the perceived usefulness of the visualization.

The participants had great fun (median: 5), and were satisfied using Muse (median: 4.5). Most agreed or strongly agreed to the statements, that the visualization is useful in reflecting on the community (median: 4), and in understanding the geo-spatial spread of the research network (median: 4). Overall, the participants found the prototype to be easy-to-use (median: 4.5).

5 Conclusion

We presented a working prototype for exploring geospatial networks. Our main objectives were to create a tool with simple interaction mechanisms, and a comprehensible and aesthetically pleasing geo-visualization, so that interested stakeholders can use it without much effort. The visualization of spatial properties supports users to understand geographical patterns.

In our case study, we applied the prototype to co-authorship data of conference publications. The geographic distribution of the institutions, as well as the visualization of the number of their publications has been found to be easily understandable. Through interactive filtering, the users were able to explore the relations between their affiliations and other institutions, and could gather insights into the collaboration network in their domain.

We see the prototype as a successful case study. The results of our usability study, and the feedback gathered in expert interviews demonstrate that this is a promising approach to exploring geospatial relationships.

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