Understanding Geospatial Interests by Visualising Map Interaction Behaviour

Eoin Mac Aoidh[1], Michela Bertolotto[1], David C. Wilson[2]

[1] School of Computer Science and Informatics, University College Dublin.
{eoin.macaoidh, michela.bertolotto}@ ucd.ie
[2] Department of Software and Information Systems,
University of North Carolina at Charlotte.
davils@uncc.edu

Abstract. We have developed a system which analyses how users behave when using a geospatial interface. Mouse movements and operations performed by users are assessed as a proxy to implicitly determine their interests, and personalise their spatial content accordingly. Users' interface behaviour can be visualised to gain a better understanding of the correlation between their actions, intentions and interests. The focus of this paper is a visualisation tool, which is a component of our map personalisation system. This tool gives a visual depiction of users' interactions with a spatial interface, and highlights the mapped objects upon which those interactions focus. Our motivation for this analysis is to help system designers discover hidden information about users' intentions, and to use such information to improve map personalisation engines.

1 Introduction

Given the increasing popularity and growing choice of spatial information interfaces in recent years, it has become increasingly important to provide an efficient, user friendly interface. For the end user it must provide the necessary browsing tools and should be able to understand the user's information requirements to provide personalised content to suit the individual user. Ideally, it should also provide important feedback about the users to the system developer. This feedback enables the developer to understand the target audience requirements, test and develop new tools and meet their requirements with personalised information content, e.g. if a developer is aware of certain hot-spots on a map that are of interest to users, he could develop a fisheye view over such spots showing greater detail and improving user satisfaction. Well-designed interfaces lead to meaningful interactions from the user, these interactions provide information-rich content disclosing user interests and intentions. Thus our motivation is to obtain a clear visual picture of users' interface behaviour with interactive maps in order to understand how best to meet their spatial information needs.

In this paper we outline our visualisation tool which provides an informative, interactive visualisation for the developer, allowing for exploratory data analysis of end users' interactions with a geospatial interface. Our research goal is to analyse users' map browsing behaviour in order to identify their intentions. More specifically, based on their mouse movements and behaviour at the interface, we wish to identify the particular objects and the portion of map (geographic area) of most significance to each user, as well as the type of task they are carrying out (e.g. exploring, route finding, retrieving and comparing specific objects etc.).

Our approach to harvesting information from user's interface behaviour is based on non-spatial implicit interest indicators, as discussed in detail by Claypool in [1]. These techniques are put into practice by systems such as [2, 3] using web-based, non-spatial information. We adopt similar techniques for spatial data, with a particular focus on mouse-based interaction as described in [4]. Implicit interest techniques have been used with spatial information for personalisation purposes by Weakliam et al. in [5]. We extend this work by focusing on interests determined by mouse behaviour, and the visualisation of this behaviour.

Authors such as Cox & Silva [6] and Chen et al. [7], have shown a correlation between user's thoughts, eye movements and mouse movements with non-spatial data. Cox & Silva identified a number of behavioural characteristics based on user's mouse movements. Hirose et al. [8] deal specifically with spatial information. They define navigational 'Operation Chunks' as sequences of pan, zoom, and select operations which are examined to gain an understanding of the user's intentions.

Our research combines the inferences that can be made from a user's mouse movements with the additional implicit information that can be gleaned by analysis of the user's map navigation patterns. By visualising user interactions "patterns and clusters" of hidden data can be revealed [9]. For example, Descartes [10] is a visualisation tool providing "automated presentation of data on maps, and facilities to interactively manipulate these maps". The visualisation tool provided by systems such as Descartes is aimed at end users. In contrast, our visualisation concept is aimed at developers for the visualisation of spatial usage behaviour and interaction patterns of end users, with a view to using this information for the personalisation of spatial content [5].

2 Approach

The visualisation tool we developed is part of a map personalisation system, whose interface and architecture are described in [4]. Initially conceived as an aid in the development phase of our algorithm design for calculating user's spatial interests, this visualisation interface has revealed a lot of useful, otherwise-hidden information about users' interactions. In particular, it has proved itself extremely useful in fine-tuning our approach. The visualisation tool is independent both of the spatial dataset and of the user interface. It could be added as a plug-in to any spatial interface providing map-browsing capabilities. The innovative aspect of our approach is the manipulation and visualisation of the information collected from user interactions. Figure 1 shows a visualisation of a user's mouse movements in relation to a spatial dataset.

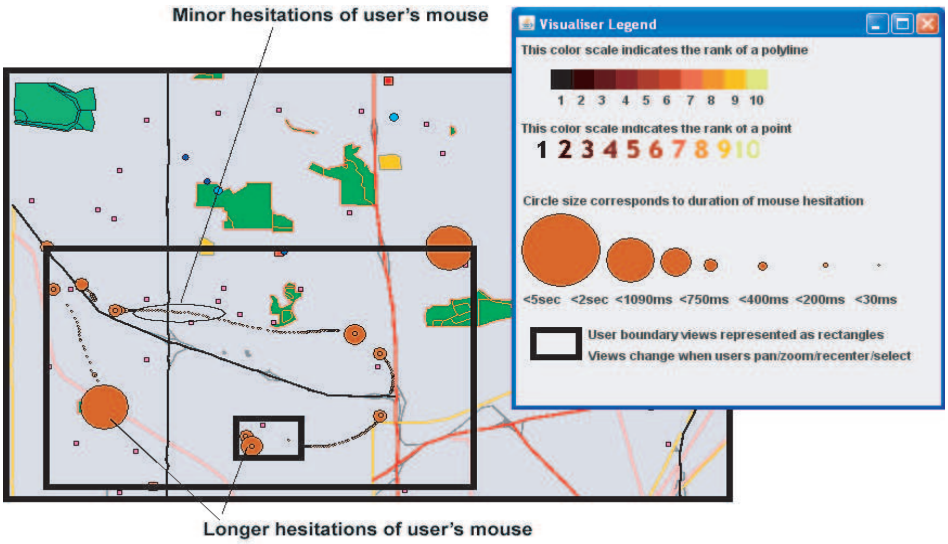

Fig. 1. A visualisation snapshot produced using our visualisation tool. The map legend is superimposed on the visualisation. The marked view boundaries and circles representing mouse hesitations give an indication of the user's focus of attention. Colour imagery allows a much greater range of information to be visualised, including chloropleth layers ranking the mapped objects according to user interests.

Interactions are logged during each user session. The raw data recorded include the latitude and longitude of the mouse cursor over the map, and its duration in each position, the co-ordinates and contents of each view of the map, and its scale (which change as the user pans and zooms around the dataset). The time sequences of actions such as pan and zoom are also logged for behaviour analysis purposes. All of this logged information can be visualised in its raw state using the visualisation interface. It is overlayed as a transparent layer over the user's dataset. This gives an overall view at a glance of where the user's attention was focused during a session, as depicted by Figure 1. The sequences of small dots indicate minor hesitations in the trajectory of the users mouse, while the larger circles show longer hesitations (see Figure 1).

We have implemented and tested a simple algorithm described in [5], which takes this raw data as input, and outputs an ordered list of the objects in the map (points, lines, and polygons) deemed to be of interest to the user. This list of interests is a function of the distance between objects in the map and various points where the user hesitated momentarily with the mouse. The distance is weighted according to both the varying map scale and the duration of the mouse hesitation in a given position. The objects identified as being of interest to the user can be visualised as an overlayed chloropleth layer on the user's dataset. The varying colour hue values for the chloropleth map are based on the scores the objects received from the algorithm.

3 Conclusion

In this paper we have provided an overview of our geovisualisation tool for user map interactions. The system produces interactive visual descriptions which reveal hidden, valuable information about users for system designers and providers. This information is obtained implicitly, without interrupting the user, and can be used for purposes such as market research and dataset personalisation [5].

We are currently conducting experiments to infer users' contexts and task types from their interactions, by comparing their sequences of actions, indicating their behaviour with automatically produced chloropleth maps revealing their interests based on their movement patterns as calculated by the algorithm. This might help identify the kinds of tasks users are undertaking.

In addition to behaviour analysis, we wish to explore the temporal aspect of user behaviour. Intentions often change during a session as sub-tasks are completed (e.g. 'find A, find B, find a path from A to B'). We expect to identify a change in user behaviour as their intentions change over time. Various datasets are being employed in these experiments in order to compare findings across varying spreads and quantities of spatial data. Further future work on the visualisation tool could see it being deployed for analysis of user interactions with a widely used spatial interface such as Google Maps (http://www.maps.google.com).

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