Analysing Mouse Movements to Infer Spatial Interests

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1. Introduction

Information overload is a well documented problem when displaying information to users through a GUI. This is also the case for spatial interfaces. We tackle this problem by logging user's mouse movements as they interact with our system. The logged information is analysed to create an interest model expressing each user's level of interest in the map features shown to him. Based on this interest model we can filter the information returned to the user, reducing information overload and tailoring the content to suit the user's tastes. This paper focuses on our methodology used to determine a user's interests based on his mouse movements over the corresponding spatial information shown to him.

We introduce the TArcHNA (Towards Architectural Heritage New Accessibility) system. The goal of the TArcHNA project is to enhance the dissemination of archaeological heritage information. We offer a modern intuitive interface, which provides access to heritage information on the city of Tarquinia ('Tarchna' in ancient Etruscan). Access to this information is provided through the interface by interacting with a map of the region. There is a large quantity of heritage information in the database, consisting of information on burial tombs in Tarquinia. This information ranges from textual descriptions to images and videos. By maintaining individual user interest models we can filter out the less relevant information to reduce information overload, and provide more relevant content for each user.

The remainder of this paper is structured as follows; Section 2 provides the background to our research, and provides a brief discussion of related work. Section 3 introduces our methodology for information capture, visualisation and personalisation. An evaluation and analysis are outlined in section 4. Section 5 concludes with an outline of future work.

2. Background

Our system contains a large quantity of information compiled by expert archaeologists potentially available to the user. Previous work has shown that information overload has negative impacts on the user (Shardanand and Maes, 1995; Budzik and Hammond, 2000). We personalise the content returned to the user to reduce information overload. Several systems (Budzik and Hammond, 2000; Wilson et al., 2006) make use of personalisation to improve the user's experience. Before personalisation can take place, the system must be able to distinguish the user's interests and disinterests in relation to the content it provides. An interest model is constructed for each user, which maintains continuously updated information regarding the user's interests. These models are maintained using implicit profiling (Claypool et al., 2001).

Previous research has shown that a strong correlation exists between eye movements and thought processing (Chen et al., 2001). Research projects such as (Claypool et al., 2001; Mueller and Lockerd, 2002; Arroyo et al., 2006; Chen et al., 2001) have documented a significant link between user's mouse movements and eye movements. These projects examine the correlation between a user's mouse movements and his level of interest in the web data displayed. The results are encouraging and show that incorporating mouse movement information can lead to a significant improvement in determining user's interests with non-spatial data. TArcHNA applies these techniques to spatial data. Several adjustments, as discussed in section 3, are made to the techniques used with non-spatial data in order to improve their accuracy and facilitate their use with spatial data.

Figure 1. Screenshot of the TArcHNA User interface

3. Methodology

The TArcHNA system is built on a client-server architecture. It includes an Oracle 9i spatial database, an information repository of non-spatial data (heritage information concerning the tombs shown on the map), and an intuitive interface, which permits the user to interact with the spatial information, to provide access to the non-spatial information. It is implemented primarily as a desktop system. A simplified mobile system is also under development. Figure 1 shows a screenshot of the interface. The spatial side of the interface is on the right. By clicking on a tomb object on the map, users can view its related heritage information in the information browser on the left.

Our system makes use of implicit profiling (Claypool et al., 2001). No explicit input is required from the user. As the user interacts with the system, panning and zooming the map and clicking on tombs to acquire information, his actions are logged. Particular attention is devoted to the user's mouse movements. By logging the location of the

mouse at all times we can, by inference (Arroyo et al., 2006), find the focus of the user's attention for the duration of his session.

In addition to continuously logging the latitude and longitude of the mouse pointer, we also log the exact time the mouse is moved or clicked. This information is used to calculate the duration of each mouse movement, determining exactly how long the mouse rested in a given position. The coordinates of the corners of the user's view of the map are logged each time a navigational operation (i.e. pan or zoom) takes place. These coordinates determine the frame boundaries. They can be used to calculate the contents of a user's view frame at any particular point during his session.

The location of mouse movements and frame boundaries indicate the user's focus of attention during his session. Frame boundaries give us a crude indicator of the region focused on by the user. Mouse movements give a greater indication of the user's interests within each of these frames. Our visualisation tool (figure 2) shows in detail where the user's mouse rested during a session, and by association, which areas of the map were viewed. The circles represent positions where the mouse rested. Their size is proportional to the duration of the mouse resting in that position.

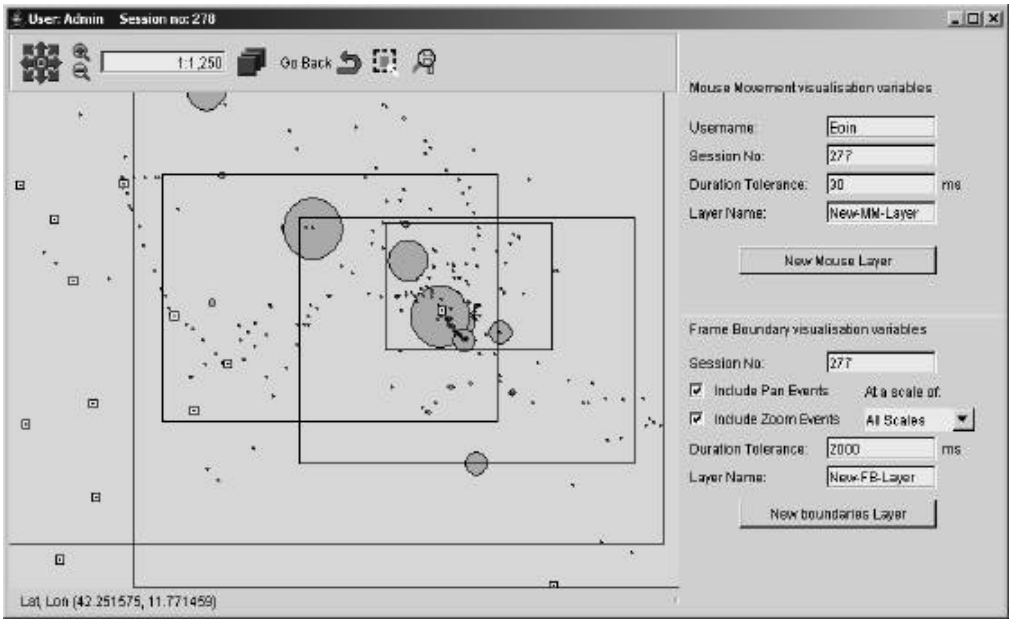

Figure 2. TArcHNA Visualisation tool: Showing the user's mouse resting positions and frame boundaries for an earlier session.

This visualisation of the user's interactions also helps determine which of the (tomb) objects displayed are of greatest interest to the user. By ranking the objects based on analysis of the log files, we can return personalised content to the user, tailoring the information returned to suit his interests. We determine an object's importance by assigning it a value based on the distance between the object and all mouse points in the same frame boundary. These distances are weighted, giving a greater weight to points

where the mouse rested longest. Further weights are applied according to the map scale when the action took place. Actions at a small scale are given a greater weight. The sum of the weighted distances for each object determines the user's interest level in the object

4. Analysis

An initial evaluation of our methodology is currently being prepared. Our test group consists of twelve users. Each user will complete ten tasks over ten different sessions. The tasks involve finding a specific piece of information on a named tomb, such as "Who is thought to be buried in 'Demoni Azzurri', locate three tombs in its vicinity from a similar era." Each user's tasks have a theme, drawing them to tombs with certain features in common. The volunteers will be uninformed that their mouse movements are being logged, as we do not wish to alter their browsing patterns, detracting from the validity of our results. The completion of these tasks by the volunteers will generate realistic user data for 120 sessions for analysis. As each user's tasks are themed, we would expect a clear distinction to emerge between features of interest, and those of little interest to a user.

Over a number of sessions we hope to show that it is possible to discern a user's preferences to some extent based on his mouse movements. This information can subsequently be used, in conjunction with other implicit indicators to strengthen spatial data recommendations.

5. Conclusions and Future Work

By analysing user's spatial interactions we create an interest model. It is subsequently possible to personalise the data set returned to the user, eliminating extraneous data that is of little interest to the user, and promoting the accessibility of further information deemed to be relevant to the user by his model.

While our case study is based in the cultural heritage domain, it is applicable to other areas, such as pubs or restaurants in a major city, by changing the dataset. We feel that our work will be particularly beneficial when applied in conjunction with other implicit techniques in order to improve the reliability of spatial data recommendations.

Possible future directions for our work include: 1) Exploring the implicit indicator value of mouse trajectories. 2) Studying the introduction of line and polygon objects (e.g. roads and parks) for comparison purposes with tomb objects (points). 3) The implementation of interaction logging for mobile users, relying on GPS position and stylus taps to infer user interests.

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6. References

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Biography

Eoin Mac Aoidh is a PhD student at UCD Dublin; His research interests include GIS interfaces, user modeling and personalisation.