Interpretation of Spatial Movement and Perception in Location Based Services

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***Abstract*—Location Based Services should deliver pertinent information to the user at the right place and at the right time. Such is the range of available content, that it must be filtered and prioritised according to the user's context to reduce wait time and eliminate the delivery of unwanted information. While some contextual information can be inferred from the device sensors, such as location and time, a deeper understanding of the user's context can be inferred by combing these sources with an implicit interpretation of the user's actions. This paper proposes an experiment to compare the user's actions in a real world environment to his actions in an identical virtual world, enabling accurate contextual inferences to be made. The real world study allows an analysis of real movements, which can be correlated with movements in the virtual world, with a greater potential for additional psychological analysis as part of the virtual world.**

I. Introduction

As the proliferation of location aware mobile devices increases due to continuous technology improvements, the demand for Location Based Services (LBS) is increasing. The goal of a LBS is to deliver appropriate content relevant to a specific location (usually the user's current location) at the time when it is required. For example, a LBS might deliver information on nearby restaurants to the user, however, a well designed LBS must take account of more than just location. Several other contexts, such as time of day, menu preference, and whether the user is hungry or not, in this example, are crucial to the development of an intelligent service. The LBS must employ any contextual information which can be gleaned implicitly to its advantage. In this case, if it can be inferred, based on device location, that the user has been sitting in a restaurant for the last 45 minutes, it is likely that the user has eaten, and that restaurants are no longer a priority for the user. Therefore the order of priority content must be recalculated according to the user's changing context.

LBS are designed for use on a mobile device, over a wireless network. Transmission of information is often affected by poor network coverage and slow processing on the device. Furthermore, the quantity of spatially referenced information available is continuously growing. As a result, it is crucial for the most important content to be prioritised for delivery to the user's device to reduce latency for the user. Moreover, irrelevant information must be elided to avoid swamping the user with information. In order to provide such a contextual, personalised LBS, the user's context, intentions, interests and preferences must be accurately interpreted from all available sources. We propose the development of a testing environment for the interpretation of a user's spatial movements and perceptions, both in a real world and in an identical 3D virtual environment. By understanding the user's actions and correlating them to what the user can see in the world around him, in relation to what is visible on the device screen, issues such as the user's concept of proximity, i.e. what services are 'nearby', and relevance, i.e. features that are used for orientation purposes, those which correspond to features/services of interest, and those which are irrelevant, can be explored. An improved understanding of these user context issues paves the way for the delivery of an improved LBS, adding value to the service, and enhancing the user's experience.

II. Related Work

Implicit Interest Indicators (III) [1] are employed by many applications with a user modelling component. They are a means of interpreting the user's interest in a particular item. For example, the printing of a Webpage as an III signifies an interest in the contents of the page [1]. In the context of a spatial browser, zooming in on a specific area signifies an interest in its contents [2] [3]. By studying sequences of operations, it is apparent that certain combinations of operations have different meanings, depending on their order of execution [4]. Furthermore, the strength of inferences made based on user interaction varies depending on the context in which they were executed [2]. For example, it has been shown that at times when the mouse is not actively engaged in interface manipulation, user's eye movements, and consequently the mental processing of the information on screen is connected to the location of the mouse cursor [5]. At other times, however, when the mouse is being actively engaged to pan and zoom through the map for example, its location in relation to the contents of the map is not as indicative of the user's objects/areas of interest [2].

The cognitive processes involved in the human brain while processing traditional 2D maps on paper, and in digital form are explored in [6] [7]. The authors explore the possibilities of exploiting Cognitive Load Theory (CLT) for more

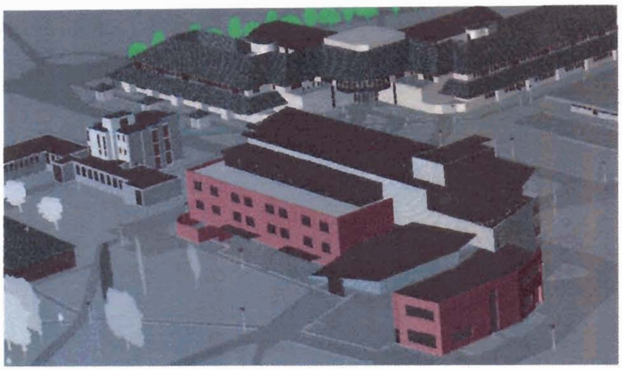

Fig. 1. A screenshot showing a section of the 3d campus model.

comprehensive and robust methodologies for 2D map construction and analysis. Human cognition in relation to virtual 3D environments is explored in [8]. The human perception of directionality between virtual landmarks is exploited for the improvement of spatial learning. The test environment proposed in this paper is concerned with the inferences about the user's notions of spatial perception in both two and three dimensions which can be made from the *physical movements* of the user through both real, and virtual 3D space. The inferences which can be made from user's physical interactions with a map interface, including mouse movements and map manipulation interactions, were explored in [2]. It is intended to bring this concept of physical movement analysis for the interpretation of the user's spatial perception to both the real, and virtual 3D space for experimentation.

III. Proposed Experiment

The test bed for the proposed experiment is a university campus. An accurate 3D model of the campus has been generated from LiDAR point clouds. The model covers an area of 500m by 700m, containing 14 buildings represented in exceptional detail. The internal representations of some of the main buildings have also been built. This gives us an identical, accurate 3D virtual representation of the real world campus, a section of which is shown in Figure 1. Such is the scale and detail of the model, that experiments could be carried out at scales varying from an area covering 5m to 500m, or even internally within the buildings, over multiple floors.

In the proposed set of experiments, users will carry a mobile device offering an interactive 2D map of the campus with information on all of the points of interest. A number of predefined tasks will be carried out, requiring them to navigate through the campus. Similar tasks will subsequently be carried out in the virtual environment. The same 2D application on the mobile device will be available to the user. Their navigation through the real world environment will be assessed, and compared to their navigation through the virtual environment at a range of scales. Of primary interest are physical movement patterns which could act as implicit interest indicators about the user's context, and the contents of the map on the mobile device in relation to the objects which the user can see in the real/virtual world. Such an experiment comparing and contrasting navigation in identical real and virtual worlds is of importance, as further analysis can be conducted in the virtual world which is not possible in a real world scenario. Analysis including eye tracking and EEG monitoring in the virtual world would follow, which are not feasible in the real world as the equipment is intrusive and cumbersome. Inferences about the user's eye movements and brain activity in the real world, e.g. for navigation, can be made if the correlation between real and virtual world performance is well tested and documented.

IV. Conclusion

Location Based Services must deliver contextually relevant content in order to provide a useful service to the user, minimising download time and reducing information overload. Certain fundamental inferences about location and time etc. can be made based on the device sensors. Our goal is to enrich this contextual information by implicitly inferring additional information about the user based on the relationship between his/her physical movements and corresponding interactions with an associated 2D map on a mobile device. We propose an experiment to examine the relationship between physical movements through space and 2D map browsing in identical real and 3D virtual worlds. By assessing the correlation between the real and virtual worlds, it could be possible to conduct an additional psychological analysis on interactions in the virtual world using equipment which would be inappropriate in a real world scenario.

Acknowledgment

Research presented in this paper was funded by a Strategic Research Cluster grant (07/SRC/I1168) by Science Foundation Ireland under the National Development Plan. We gratefully acknowledge this support.

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