Mind the Gap: Mobile Applications and Wayfinding

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Abstract. This paper will focus on Global Positioning System (GPS) and it's applied use as technological assistance for dynamic wayfinding. Through an overview of the cognitive strategies utilized in wayfinding it identifies some of the affordances offered by mobile GPS devices. As background it discusses map use and the acquisition of spatial knowledge, and additionally outlines the nature of spatial data interpretation required by mobile devices. It establishes that GPS applications exhibit spatial and temporal variations, and that this gives rise to inaccuracies. The discussion will then focus on generally characterizing these errors or 'seams' which are generated between the user, the interaction and the environment. It will summarise by outlining some possible features of GPS interfaces and the potential for communicating these seams as contextual attributes.

1. Introduction

Currently there is a wide body of research on how humans reason about space, how they navigate through familiar and unknown environments, how they act in spatial environments (real and virtual) and how they communicate spatial information. In this context, the particular focus of this research on wayfinding establishes a valid method to assess navigational knowledge and more generally spatial reasoning. The current challenge is how these abilities can be supported by technical systems and devices.

2. Wayfinding

Wayfinding i.e. getting from some origin to a destination, is one of the prime everyday problems humans encounter [1]. It is a purposive, directed and motivated activity [2]. Humans use different wayfinding strategies depending both on their own individual spatial awareness, and also their knowledge of the environment they are traveling through. Wayfinding knowledge acquisition is in three stages; identification of landmarks, a procedural route knowledge, formed when traveling between two landmarks, and a structural survey knowledge, which is equivalent to inferring a map [3].

Landmarks act as primary features in the wayfinding task, and work as nodes for organizing other spatial information into a layout. They may be noticed or remembered because of dominance of visible form, peculiarity of shape or structure, or because of socio-cultural significance [4]. Paths are static linear structures in an environment; they may be streets, footpaths, pavements, canals, rivers or railway tracks.

The behavioral pattern or movement, performed by moving along a path is called a route [5]. Route knowledge is usually gained by personal exploration of a new area, and is ordered sequentially and often structured around features such as landmarks. When moving along a path an individual experiences an organised sequence in which phases follow each other meaningfully in an order [3]. Route following in wayfinding also involves recognizing an origin and a destination and identifying districts and sequences of features that make up the route.

Following successive experiences of sequential routes, knowledge about the environment is integrated into configurational survey representations [3]. These permit the direct retrieval of spatial relationships between points without reference to the routes connecting them. In more familiar environments a person will utilize a highly configured egocentric mental representation of an area called a cognitive map. This is the generalized picture of the exterior physical world that is held by an individual [7]. It incorporates configurations of landmarks, routes, regions, and includes comprehension of distances and directions, linkage, connectivity and scale [4]. A further important anchor point in wayfinding is that of the start point location. At route level it functions as the origin in sequential features, and in survey or cognitive maps it's location is comprehended as part of the configurational structure.

3. Wayfinding Assistance

An increasingly critical context to human spatial cognitive abilities is the level to which they are technically supported. When considering the wayfinding task it is sensible to assume that there is a broad correlation between spatial knowledge acquired when exposed to the type of spatial information afforded by mobile GPS devices and that provided by map-like representations. A map is a third source of information about the environment, besides the mental representation and the environment itself. From a map, people acquire survey knowledge encoding global spatial relations [6].

There is differentiation between learning that takes place at the eye level perspective and learning that takes place by examining configurations and layouts, such as when using maps. Specifically map user's cognitive maps do not improve with extensive exposure to maps displaying the spatial relationships. Map users also make errors when judging orientation, although they are far better at judging metric route distances. They are most error prone when required to change their perspective on the representation and translate their knowledge into a response within the environment [6].

4. GPS

The paper discusses the role of Global Positioning Systems (GPS), since it is an increasingly quotidian technology used for wayfinding. Applications that rely on GPS range from widely available guiding and mapping applications, through location-based services to augmented-reality style presentations [8]. This paper will focus on commercially available mobile devices incorporating GPS receivers.

Such devices are considered most useful for someone finding their way in an unfamiliar environment. The GPS receiver interface assists wayfinding by providing real-time location data of the user and displaying this as an overlay onto some form of map representation of the real environment. Many GPS devices are also voice-assisted and provide real time route directions at decision points. In terms of display, this is usually a cartographic representation, but three-dimensional schematic maps and topographic information are also used in some devices.

A critical factor in GPS is that it enables user input to update the device, either with routes or waypoints, prior to undertaking the wayfinding task. This enables the user to integrate external contextual information into the GPS data creating an overlay of individually useful information onto the standard cartographic representation.

5. Mobile Devices and Wayfinding Assistance

A physical device, such as a pencil, has a location that is unique to that space, and its influences and effects are only through the physical space in which it resides. A mobile device can be considered as having an existence and presence in terms of many spaces [9]. Since it is not purely a physical device, the GPS receiver should be considered as simultaneously inhabiting a real world and some form of virtual world (or indeed multiple virtual worlds). In the case of GPS a typical device a real time trace of the user's motion in time is overlaid onto a graphical representation of the environment. The user is therefore required to at some level to perceive this difference and understand that this requires them to interpret the data differently depending on whether it is real (the environment and the user) or virtual representation (the GPS interface) of data. As discussed above GPS offers the opportunity to further interact with the virtual representation layer of data, through the input of personalized information. As GPS technology use becomes more sophisticated over time it would be expected that the quality, content and accessibility of this data input will start to significantly affect the potential usefulness of the application. Rather than being layered on top of a space, it will come to transform both the space and the ways that people act within it [10].

6. Accuracy, Consistency and Usefulness

The discrete nature of computation means that both specification and implementation of computer systems tend to focus on events that occur at specific times. However most mobile applications detect or measure status phenomena i.e. they are things which constantly have a value that can be sampled. The translation of status phenomena into events is problematic and is often done accidentally within systems, with the consequent probability of errors [9]. This may contribute to the fact that the fundamental infrastructure and services that make up ubiquitous and pervasive technology exhibits a great deal of spatial, temporal, economic and organizational variation [10]. These errors include breaks in functionality or connectivity, imprecise positioning and errors in recording and representation. Such application failures have been referred to as 'seams' [10], a term which acknowledges the junctures that are created between technology, human and environment. In the use of GPS receivers the errors that occur can be broadly categorised as:

GPS Accuracy

- Where GPS signal availability is weak or non-existent in environment
- Slow and unpredictable temporal characteristics of GPS signal
- Inaccuracy in GPS signals identification of location

Cognitive discrepancy between real and represented data

- Failure to cognitively interpret disparity in accuracy between real and represented information
- Cognitive inability to successfully switch perspective between real and represented environment

Environmental usefulness

- Where real environment is easier to navigate without technological support
- Where GPS lacks a relational human scale in the immediate physical environment

These errors or 'seams' define the limits of practical usability of such technologies, and consequently wayfinding strategies need to adapt to accommodate these inaccuracies.

7. Context Adaptive Attributes

Context is any information that can be used to characterise the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and the application themselves [11]. When considering the interaction between the user and the application significance needs to be placed on the impact of the 'seam' or error on the wayfinding task. In this sense the 'seamfulness' of the technology establishes a dynamic spatial and temporal context, independent of that of the environmental infrastructure or cognitive setting. Since the accuracies are created through errors in the translation of status phenomena into events then it would be useful to look at ways in which a GPS device could be aware and represent status change [9].

One way in which this could be achieved is by actively including attributive information. An attribute is derived from a characteristic pattern of simulation regularly associated with a particular phenomenon which, in combination with other attributes, signals the presence of the phenomenon [12]. In attempting to dynamically present the limits of accuracy of the device, it may be appropriate to present the seam as an attribute. A good example might be representing a user's sensed position as a spatial extent rather than as a point [13]. This attribute would necessarily be dynamic and fluctuate within the parameters of the GPS signal. In this scenario the error is visibly represented in the interaction as a context specific attribute.

8. Summary

Wayfinding utilises a number of strategies, such as landmark recognition, identifying routes, integration of more complex configurational spatial knowledge and cognitive mapping. In order to discuss the nature of mobile technological assistance offered in wayfinding tasks, the paper briefly reviewed performance in the wayfinding afforded by spatial knowledge acquired from maps.

Following a discussion of the nature of information presentation of mobile devices the paper then outlined some aspects of data accuracy, consistency and usefulness in GPS devices used in wayfinding. It concluded that 'seams' exist in the interaction between user, technology and environment. If the user's experience of technologies such as GPS is to be fulfilling in a pervasive scenario, consideration has to be taken of the integration of 'seams' into the interaction. It was proposed that one of the most appropriate methods to achieve this is through attribute data, where the seams are communicated as a dynamic contextual attribute.

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