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Hearing the way: Requirements and preferences for technology-supported navigation aids

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ABSTRACT

Many systems have been developed to assist wayfinding for people with sight problems. There is a need for user requirements for such systems to be defined. This paper presents a study which aimed to determine such user requirements. An experiment was also conducted to establish the best way of guiding users between locations. The focus group results indicated that users require systems to provide them with information about their surroundings, to guide them along their route and to provide progress information. They also showed that users with sight conditions interact with systems differently to sighted users, thereby highlighting the importance of designing systems for the needs of these users. Results of the experiment found that the preferred method of guiding users was a notification when they were both on and off track. However, performance was best when only provided with the off track notification, implying that this cue is particularly important. Technology has the potential to support navigation for people with sight problems. Users should have control over cues provided and for these cues should supplement environmental cues rather than replacing them.

1. Introduction

Blind and partially sighted people face difficulty in both navigating through environments and knowing what is in their environment. This can lead to reductions in their mobility, increased danger and decreased independence (Walker and Lindsay, 2006). Previous work has suggested that blind and partially sighted people heavily rely on help from other people in unfamiliar places and face particular challenges in navigation in noisy environments (Saenz and Sanchez, 1990). This suggests that orientation may be aided through the provision of directions along the person's route. In addition, there are instances where sighted people may be unable to use vision to aid navigation due to carrying out other tasks which require sight simultaneously (Walker and Lindsay, 2006).

Location based handheld technologies provide an opportunity to use technology to support navigation using non-visual presentations. This may therefore support blind, partially sighted and sighted users. This paper presents a study that developed some prototype methods to support blind and partially sighted users in a navigation task. The methods were derived using a user requirements exercise that considered technology capabilities and limitations, user preferences and needs and views of experts. The methods were then compared in an experiment that simulated the navigation task of moving from one checkpoint to the next for blind and partially sighted users. On the basis of the findings of this research, the way in which different user needs were met was considered along with any improvements to the prototypes methods and identification of areas for future research.

2. Literature review

2.1. Characteristics of blind and partially sighted people

The population of blind and partially sighted people is on one level a seemingly homogeneous group in that they all, to some degree, cannot access information in the same way that the rest of the population do. However, the underlying story is quite different. Generally speaking no two people with the same eye condition

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have the same sight level and characteristics. This makes the population of blind and partially sighted people heterogeneous and therefore can be difficult to cater for user needs on an individualistic level. Bradley and Dunlop (2004), highlighted that blind and partially sighted fall into three main groups; total vision loss, central vision loss and peripheral vision loss. Within these categories are many sight conditions including glaucoma, retinitis pigmentosa and macular degeneration (RNIB, 2013a). Individuals suffering from a loss of central vision need to move their head to one side in order to see in their periphery. They also need additional support when reading and performing tasks. Unless treated, the area of central vision loss will increase until the individual cannot see anything (RNIB, 2013b). People who have a loss of peripheral vision, need to move their heads more in order to find things (RNIB, 2013c).

Once individual sight conditions are categorised more broadly into people with low vision (encompassing blind and partially sighted people but have some useful vision) and people with no vision (encompassing blind people who have no useful vision, e.g. can only see light or dark or nothing), solutions that would benefit the users of these two groups become more homogenous. For instance, when considering textual information, those with low vision will, generally speaking, benefit from clear visual information (e.g. large typeface and clear fonts) (RNIB, 2009). People with no vision need to access the same information in an alternative format (e.g. Braille, other tactile information or audio) (RNIB, 2012a). The same may be true of technology-supported navigation systems.

2.2. Supporting navigation for visually impaired users

Sighted people use their vision when navigating and this has been suggested to support the development of mental maps (Lahav and Mioduser, 2004). When visual information is not available, other senses, such as hearing and touch, must be used. However, the mapping between a communication using hearing and touch does not always have such an accurate or detailed direct mapping between the user and the environment. Therefore there is a need for research to understand and propose appropriate methods of using non-visual media to communicate spatial information.

Strothotte et al. (1995) found that users have a need for information regarding landmarks, topographical information, the user's current location, roadworks, street names and directions. Previous work has suggested that in particular, it may be difficult to articulate descriptions of some environments, for example, irregularly shaped buildings and curving paths (Golledge et al., 1996). In addition, words used to describe spatial configurations (such as ‘near’, ‘around’ or ‘the red building’) may be ambiguous or inappropriate for use when describing environments to blind or partially sighted individuals (Golledge, 1993). An alternative approach of using the clock system (Sanchez, 2009) has been proposed and is consistent with the theory that people with sight problems generally understand spatial configurations with respect to their own bodies (Millar, 1994).

Tactile maps provide users with information regarding the relative locations of objects in space (Ungar, 2000). Maps that provide audio clues to location (e.g. sounds appropriate to the environment, such as the sound of traffic or people) have also been proposed to support understanding of spatial configurations. These have been demonstrated to support the formation of mental maps for blind and partially sighted users (Jacobson, 1998).

The opportunities presented by new technologies to support navigation have also been investigated. The System for Wearable Audio Navigation (SWAN) made use of non-verbal audio to portray information. It was found that the use of beeps was less distracting than speech and also easier to distinguish from environmental sounds (Discovery Channel Canada, 2007). This method used the concept of waypoints to guide users; with beeps increasing in frequency as they were approached. Goulding (2010) also used the concept of waypoints in a visually based system that used a mobile device to represent arches along a route. Walker and Lindsay (2006) proposed the use of a capture radius around waypoints to ensure that users were able to detect them when they were nearby.

The Personal Guidance System (PGS) has also been used to test a number of ways of portraying information to blind and partially sighted users using spatial displays. One study compared the use of non-verbal audio, synthesised speech and/or vibrations which were initiated either from the position of the hand or the torso. It was found that participants were able to complete the tasks faster with auditory cues and generally liked spoken information about the distance to the next waypoint (Loomis et al., 2005). Ertan et al. (1998) also developed a system of navigation which made use of a haptic directional display which was integrated into a wearable vest.

Beacon based technologies such as ORTI (Kemmerling and Schliepkorte, 1998) and RNIB REACT (RNIB, 2012b) have also been developed. These provide information to users about their locations via units which are situated in fixed places. Whist these systems can provide users with context-specific information, the usefulness of such systems has been questioned due to the need for users to be aware of the existence and location of these beacons (Worsfold and Chandler, 2010).

GPS technologies which can support navigation for blind or partially sighted people are also commercially available. These include the Trekker Breeze and the Kapten Plus. The Kapten Plus is voice activated and provides spoken turn-by-turn navigation (RNIB, 2012c). The Trekker Breeze uses speech to provide information about the user's surroundings including road names, junctions, and points of interest. It also allows users to record routes and landmarks and will provide step-by-step journey instructions (Humanware, 2012). Drishti, a research based system, took this one step further by optimising routes based on real-time information. It was designed to select routes based on user preferences as well as dynamic events and obstacles, for example, roadworks or high volumes of traffic. It also warned users of hazards in their locale (Helal et al., 2001).

Strothotte et al. (1995) found that users have a preference for information to be provided using synthetic speech rather than non-verbal audio or vibratory cues. Conversely, Holland et al. (2002) found that users were able to use non-verbal sounds to portray information regarding the direction, distance and location of landmarks with respect to the user. Their system used directional audio and trials indicated that users were able to discern the direction of sounds. However, the authors did note the challenges presented by multiple auditory cues that could quite quickly lead to a cluttered audio output. Spatial sound has also been suggested to be useful in allowing users to differentiate between multiple sounds being played simultaneously as well as in series (Brewster et al., 1995). Tran et al. (2000) suggested that in order for the perceived location of a sound to match the target location in the real world it should be: easy to localise and follow; different enough from environmental sounds; easy to hear over other noises; and should not distract or frustrate the user. Although users have been found to more accurately locate directional sound when it is of a higher frequency and relative wide-band, people tend to prefer lower frequency sounds as they are deemed to be less annoying (Tran et al., 2000). This demonstrates that it is important to consider both user preference and performance in developing and evaluating any navigational cues. Earcons, which are abstract sounds that can be used to represent parts of interfaces, have been demonstrated to be particularly effective at