Prototyping and Evaluation of Landcons: Auditory Objects that Support Wayfinding for Blind Travelers

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Introduction

Sighted people use vision to quickly access a rich amount of information about their environment. Blind users are deprived of this information, which compromises their abilities both to understand their surroundings and to navigate within them. Alternative sensory information, such as sound or touch, is substituted for the missing stimulus [7]. This information supports navigation in the immediate vicinity, e.g., the location of obstacles and hazards, but does not provide the location of distant unique objects which sighted people often use as navigating landmarks. The opportunity exists to electronically augment a blind user's environment with information about distant landmarks, e.g., information that would allow a blind person to turn in a circle, listen to distant landmarks, and then proceed in a direction guided by a chosen landmark.

Technological solutions in several key areas permit access to contextual information about environments. These include: location sensing systems [3]; open and rich geographic databases; high performance portable computing devices; ubiquitous high speed networking; and high quality computer-based sound rendering. While these solutions are not new, past and continued development permits affordable access that was previously prohibitive for all but very wealthy consumers of technology and the research community.

Previous work, referenced subsequently, suggests that the current technology portfolio can be applied in an affordable way to augment a blind traveler's environment with relevant navigation information. This research will focus on developing and evaluating such a navigation aid.

The rest of this document is organized as follows. First, the background literature supporting this work is presented followed by a description of the proposed navigation aid. This is followed by a presentation of the current status of the research and then by a discussion of this work's contribution to the field. Finally, a brief description of the author / consortium applicant is presented.

Background

A review of related work suggests several important features and concepts to consider in designing the landmark navigation aid.

- Navigational tasks decompose into two main areas: (1) nearby hazard / obstacle avoidance and (2) navigating to remote destinations [6]. Type 1 is the purview of the Orientation and Mobility (or O&M, previously known as foot travel) professional practice of occupational instruction, e.g., canes and seeing-eye dogs. [2]. Type 2 represents the perceived opportunity space for this research.

- Significant research has been undertaken to evaluate methods for auditory information display. Earcons [1] and sonification [5], provide rich information detail via terse audio representations. Speech can provide information with minimal ambiguity, but imposes higher cognitive load. Several navigation systems for destination planning and wayfinding have been developed for both academic and commercial applications [6], [8], [11], [13], http://www.humanware.ca, http://www.senderogroup.com. Feedback is provided via sound, touch or a combination of the two. Users of systems providing tactile feedback outperform those using systems with audio feedback. [12].
- Audio feedback that provides location information through variations in musical quality or pitch has been shown to be a good mechanism for providing information on relative differences and situational positioning. [9].
- Using silence during audio display has been found to be an effective mechanism for helping users to maintain direction in the user studies performed in our labs at the New Jersey Institute of Technology.
- Recent research has investigated the manipulation of user-selected music for navigational feedback for sighted users with spatial audio being used to guide travelers through the simulation of the music origin as the navigation target. [4]. It is unclear whether this passive type of support will work effectively for blind users because of its interference with other useful audio navigation sources.
- Researchers have demonstrated display of continuous values to subjects via an audio abacus[14]. During blind-user navigation, this mechanism could be used to display real, continuous values such as distance.
- A software-based real-time virtual acoustic environment (VAE) rendering system has been developed at NASA Ames Research Center [10]. This system offers developers a software-based experimental platform with low-level control of a variety of signal processing parameters for conducting psychoacoustic studies. This system has characteristics that are similar to the test apparatus being constructed.

Proposed solution

This work will leverage the research described in the previous section to assemble a new design that will give the blind navigator information about both distant and near objects in his or her surroundings. Since haptic interfaces are not uniformly found on commodity computing platforms, the problem is further constrained to eliminate haptic interfaces from consideration. The goal of this research is thus: to develop audio interfaces which will give a blind navigator wayfinding information captured from the environment to support local and distant navigation that will approach the effectiveness of the touch-based systems.

Two audio feedback approaches will be developed and tested. These have already been prototyped and found to show promise among our blind test user population.

The first approach uses an egocentric coordinate system (the navigator is at the zero point and all paths lead from the navigator), and provides feedback of a desired landmark's distance and direction through sonification. This is done by providing sound that falls off in pitch and timbre when the user orients away from the chosen landmark. Distance from the landmark is given either as a variation in clicks per time or in generated speech. Landmarks, themselves, are identified by speech, but the plan is to also explore ecologically-based sounds.

The second approach will use silence. When a landmark is chosen as the navigation destination, silence will be provided as long as the traveler is within a desired threshold of the optimum path to the landmark.

Further iteration in the use of continuous audio feedback to provide navigation orientation and guidance is expected, based on our evaluations conducted with blind users.

Status of research

A test environment has been constructed using a laptop computer and a Wacom tablet, with both cartesian and angular reporting capability. A user navigates within a virtual space that is mapped onto the tablet surface. The user is given a navigational objective to find 10 distinct landmarks. As they explore, appropriate feedback is provided via binaural headphones. Feedback includes both sonified audio as well as generated text-to-speech. Performance of the navigation task within the environment is captured via several commonly used measures: elapsed time, distance traveled, and path error.

It is realized that this miniature environment is a proxy for the real environment, and that evaluation “in the large” is optimal and may be required. If not, justification needs to be provided to support the generalizability of results to life scale. The benefit of the small environment is that many design iterations can be tested. Because the current landmarks are virtual and sonified, they have been called Landcons, akin to the labeling of virtual sounds as earcons. Eventually a landcon will represent a real landmark.

Pilot tests have been conducted with the apparatus in its current state. Over the next 3 months, the test apparatus will be finalized and a user study will be conducted. Results from this phase will be available at ASSETS 2006. A full demonstration of the test apparatus will also be available.

Contribution to the field

The most significant contribution that would come from this work is the generation of a more comprehensive auditory feedback mechanism for real-time wayfinding. Such a system can work in the small and guide a blind user along a curved sidewalk but also work in the large guiding a blind user to a key but distant location, e.g., the subway station.

A secondary contribution would be the potential application of this research to stationary settings in which a blind user could explore an environment before traversing said environment.

About the author

I am currently a part-time Ph.D. student at the New Jersey Institute of Technology in the Information Systems Department. I am also a full-time employee of Sun Microsystems, Inc., currently working in product engineering on a Utility Computing offering At

ASSETS, I hope to meet others with similar research interests and to benefit from the invaluable feedback I'll receive if accepted to the Doctoral Consortium.

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