Indoor Navigation Challenges for Visually Impaired in Public Buildings

Vikas Upadhyay  
Indian Institute of Technology Delhi  
New Delhi, Delhi, India  
vikas.upadhyay@cse.iitd.ac.in

M Balakrishnan  
Indian Institute of Technology Delhi  
New Delhi, Delhi, India  
mbala@cse.iitd.ac.in

ABSTRACT

For any visually impaired person independent mobility and navigation in an unfamiliar environment is a well-known challenge. Indoor mobility is more challenging because of increasing complexity of indoor spaces, unavailability of open standards for structured navigation support and lack of orientation and/or mobility training. Some of the essential indoor facilities that need to be accessible include public hospitals, train and bus stops and large public buildings. These places impose many challenges as often the users are first time or infrequent visitors and thus do not have prior point of interest or landmarks information. This paper covers the work we have done in the field of mobility and navigation. We present both the ongoing work and a proposed research project to understand the on ground needs of a visually challenged user. The issue is complicated by the high density of users as well as high decibel levels that is typical of public places in countries like India. The key objective of this work is to integrate the localization techniques with an appropriate user interface for easy navigation in such settings. The attempt is to create a scalable solution and is based on starting with a building map annotated with navigation related infrastructure including landmarks suitable for visually impaired as input and generate a map annotated with additional meta data that is now capable of handling the user related navigation queries to make the building accessible. This
Indoor Navigation Challenges for Visually Impaired in Public Buildings

process also should be capable of generating the augmentation required in terms of audio markers. In this augmentation process we use the International Telecommunications Union (ITU) open audio standards as well as other non-visual augmentations like haptics and sound.

KEYWORDS
Independent mobility; orientation; landmarks; point of interest information; Assistive Technology; meta data; haptics; Way-finding; VI: Visually Impaired

ACM Reference format:

INTRODUCTION
ASSISTECH, is an inter-disciplinary assistive technology laboratory at IIT Delhi engaged in finding affordable technology solutions for education and mobility of the visually impaired. ASSISTECH has achieved some success with products such as SmartCane\textsuperscript{TM} [10], affordable tactile books, OnBoard\textsuperscript{TM} [2] and DotBook\textsuperscript{TM} - a refreshable Braille display [9]. Current ongoing research projects in navigation support for visually impaired include Mobility Assistant for Visually Impaired (MAVI)[5] and Navigation Assistant for Visually Impaired (NAVI)[3]. Independent indoor mobility and navigation for visually impaired is challenging globally because of lack of navigation support in indoor environments. Typically, in Indoors the unavailability of GPS signals as well as information overload from recent vision based object recognition solutions makes the task of independent way-finding even more complex for the first time/infrequent visitor to the facility. To add to this complexity is the high people density that is typical of public places in countries like India which adds to the general confusion due to high decibel levels. Inaccessible indoor spaces can often compel them to compromise on their potential as they would tend to opt for local employment opportunities. Indoor localization has been an active area of research driven mainly by commercial opportunity to deliver content close to its point of interest - shopping malls for example. The various reported approaches address the issues of accuracy, cost, energy efficiency, robustness, maintenance and installation feasibility [7, 13, 14]. These efforts have typically focused on making indoor localization more accurate but their user interfaces do not address the needs of visually impaired. This work proposes an indoor navigation and way-finding solution which can provide not only position information but also surrounding landmarks coupled with turn by turn navigation. This is proposed to be achieved using an effective audio information system and other non-visual augmentation. This paper covers the earlier work done by ASSISTECH, ongoing research project, learning from the user trials and few open research objectives for indoor navigation.

Figure 1: SmartCane\textsuperscript{TM} device

Figure 2: Challenges in bus boarding
Indoor Navigation Challenges for Visually Impaired in Public Buildings

Position paper in CHI’19: Workshop on Hacking Blind Navigation, May 4-5, 2019,

EARLIER WORK AND SIGNIFICANCE

Considering the importance of independent mobility in socioeconomic inclusion, a key success of the ASSISTECH group is an affordable device for safe and independent mobility of visually impaired named SmartCane™. This is an ultrasonic ranging device that can be attached to a standard white cane for detection of knee above obstacles as well as non-contact detection (Figure 1). It has more than 60,000 users in India. Another mobility related project is a device named OnBoard™ that can assist a visually challenged person to board a public bus independently. The two key issues to be addressed in independently boarding a public bus relate to getting to know the route number of the incoming bus and locating its entry door for safe boarding (Figure 2). This OnBoard™ system through extensive pilot trials in Mumbai and Delhi has demonstrated a globally unique solution to support independent boarding of VI through an audio cue. Roshni [4] is another useful indoor navigation project based on infrared sensor network and on device accelerometer. Extending outdoor mobility interventions, the proposed research work tries to address the independent indoor navigation challenge.

MOTIVATION

Motivation for our indoor navigation research emanates from an opportunity to participate in ground level implementation of indoor navigation support in two very distinct facilities.

Way-finding in a hospital: In hospitals, patients as well as accompanying persons visiting the facility are usually in a heightened state of anxiety and this typically adds to the challenge of way finding to reach the intended destination. The experiments are being carried out in an ophthalmology department of a major public hospital in Delhi having footfall of nearly 2000 outpatients every working day. The major objective of this research work is to understand and create an inclusive way-finding coupled with integrated service design for a large health care infrastructure. The need for integrating service design with the challenge of way finding arose from the need for an out-patient to typically visit 4 to 5 service points to complete a full "transaction" referred to in Figure 4. In the first phase we worked on signage Figure 5 while in the second phase we are now working to support visually impaired visitors using indoor navigation support and audio markers. One interesting research issue that we would like to tackle is whether the "flow" information that is available can be exploited to provide effective navigation support to the visitors.

Public museum accessibility: Simultaneously we are also working on the navigation support for a war museum which is still under construction but is likely to have a large footfall. Accessibility requirements in this space include location based information also to be accessible as each exhibit carries information on a large number of martyrs along with associated stories. This requires integrating a comprehensive query mechanism with "random" navigation support as very often visitors are expected to have special interest in specific exhibits and details associated with the same.
LEARNING FROM EARLIER WORK

In our SmartCane™ design we had extensively investigated interface issues related to obstacle and non-contact detection [10]. Effectiveness of audio cues for short distance destination localization has been established in our OnBoard™ work [2]. Roshni [4] uses an infrared sensor network and accelerometer to assist the person to navigate inside a building by acoustic feedback through the mobile phone application. Pratyaksh [1] was an effort to create a compact wrist band to convey a sense of objects around the user by processing the depth map of surroundings. There is considerable literature available on indoor localization using the Wi-Fi infrastructure augmented with Beacons [6, 7]. In our work with the public hospital, extensive video recordings have provided us an opportunity to observe the flow as well as navigation support required in these circumstances.

Technology solutions and indoor infrastructure. It is clear that to make the solutions cost effective and scalable, it is important that the existing infrastructure where available (like Wi-Fi) be maximally used. The studies shows that strategic placement of any augmentation like an audio marker can be very effective in indoor spaces [2, 11]. Prior information about the upcoming landmarks and services in indoor space is helpful for VI users. Orientation is a critical requirement to support indoor navigation which has seen few efforts. Crowds can significantly affect the performance of localization techniques and again this issue has not been studied much.

Design and deliverable for visually impaired users. Apart from localization, effective delivery of navigation information remains a key to the success of any solution. Figure 7 shows the elements of indoor navigation service design. Non-visual augmentation like haptic and sound can enhance the effectiveness of navigation system to the VI users [12]. Our limited studies have shown that progressive disclosure of information and turn by turn navigation can help in reducing the cognitive load and can be a good reinforcement. User interfaces must be tested in order to ensure its easy comprehension. Intuitive instructions like “bear left/right” are more effective than frequent descriptive information. Audio based user interface is preferable but has limitations in noisy crowded spaces. From the past user trials and ongoing research [3] it is clear that non-visual cognitive mapping of the environment can enhance the retention of the mental map of the space even for non-frequent visitors.

OPEN RESEARCH CHALLENGE

Our research objective is to work on techniques that can analyze an annotated building map and suggest the possible augmentation required to create an accessible indoor space as shown in Figure 6. We plan to deal with not only effective use of existing infrastructure in the buildings and associated landmarks but also dynamic information like crowding and audio levels [8].
In this process of trying to address the indoor navigation challenge of visually impaired, we would also be contributing to two other areas; the semantic understanding of indoor spaces by the visually impaired and the effective user interfaces for delivery of information in such environments.

ACKNOWLEDGEMENTS

We are thankful to visually challenged community for giving us a real insight of indoor navigation problems from their perspective. We are also thankful to all research staff and volunteers involved in this project. Ongoing research work has been supported by a large public hospital in New Delhi, India.

REFERENCES