

# Pilot Evaluation of a Path-Guided Indoor Navigation System for Visually Impaired in a Public Museum

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## ABSTRACT

One of the common problems faced by visually impaired people is of independent path-based mobility in an unfamiliar indoor environment. Existing systems do not provide active guidance or are bulky, expensive and hence are not socially apt. Consequently, no system has found wide scale deployment in a public place. Our system is an omnipresent cellphone based indoor wayfinding system for the visually impaired. It provides step-by-step directions to the destination from any location in the building using minimal additional infrastructure. The carefully calibrated audio, vibration instructions and the small wearable device helps the user to navigate efficiently and unobtrusively. In this paper, we present the results from pilot testing of the system with one visually impaired user in a national science museum.

**Categories and Subject Descriptors:** K.4.2 [Computers and Society]: Social Issues - Assistive technologies for persons with disabilities

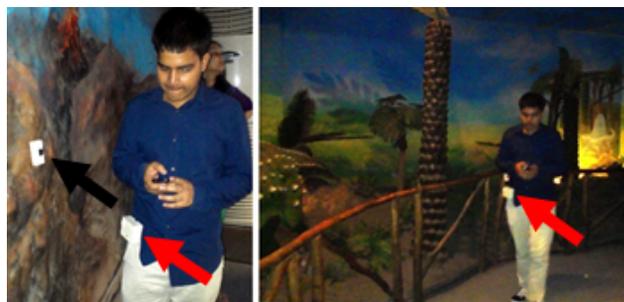
**Keywords:** Visual Impairment; Indoor Navigation

## 1. INTRODUCTION AND RELATED WORK

Navigation and wayfinding to reach a desired destination is a considerable challenge for a visually impaired person particularly in an unknown indoor environment. Path finding is a composition of several cognitive processes like map building, landmark identification, obstacle avoidance and interaction with by-standers to ask directions [8]. Most of the globally present signages are vision based and thus are inaccessible to them. Locating an accessible signage (tactile, audio) again poses a problem. Navigators currently rely on sporadic help from bystanders and use path integration to follow a given direction [8]. This causes anxiety, embarrassment and makes them reluctant to go alone in an unfamiliar building [6].

Existing commercial navigation systems based on GPS (eg. Sendero [2]) have made navigation a lot easier in outdoor environments. But their major shortcoming is that they can only identify very specific landmarks encountered by the user and typically do not work indoors. Several attempts have been made to address the problem of indoor navigation for the visually impaired. However, no single solution has found wide acceptability and long term deployment for use. Most

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**Figure 1: User navigating with the aid of the system. User module (red arrow) and wall module (black-arrow). Left image is the start position of the exhibition.**

of the systems present today are either only landmark identification systems with no path-based guidance (eg. RFID [7], infrared based systems [3]) or are inaccurate for an indoor environment (eg. dead-reckoning [5], Wifi [10]). Few systems exist which are both omnipresent (which could localize the user accurately from any point in the building) and provide step-by-step path based wayfinding. These systems are bulky to carry [4] or expensive to operate [9].

**The system:** We have developed a portable and self-contained indoor navigation system for the visually impaired [6]. Comprising a network of wall mounted units and a user module coupled with a mobile application (Figure 1, left image), the system downloads the map of the building, localizes the user within the building, takes the destination as input from the user, and then helps him/her to independently navigate to his destination using step-by-step navigational instructions. Earlier work field tested the deployment with 10 visually impaired users in a university building [6]. In this work, we present the qualitative results from pilot testing of the deployment in a public museum at New Delhi.

**The museum:** National Science Center (NSC), located in New Delhi, is part of the National Council of Science Museums, Govt. of India [1]. Inviting more than 500,000 annual visitors, it aims to popularize science among the people of India in general and among the students in particular. NSC consists of 4 floors containing 7 exhibition galleries, each build on a unique science theme, covering a total area of 6409 sq. m. There is a single navigational path which starts from the ground floor, takes the visitor up to the fourth floor using the escalator and brings him/her down to the ground floor via distributed small stairs, while covering all the galleries in between. Exhibits are either located on the narrow track connected to the main path or are spread across wide halls situated on the path.

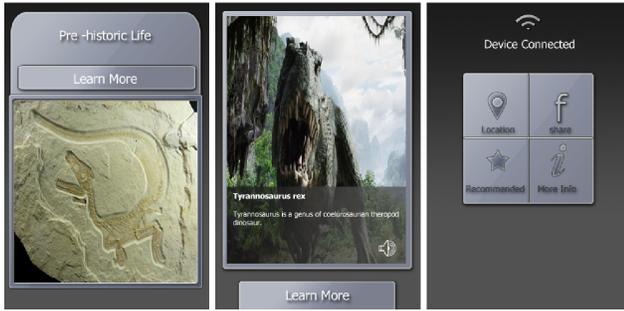


Figure 2: Sample screens from the mobile application.

## 2. USER INTERFACE

Figure 2 shows sample screens from the mobile application interface for navigating in a museum. All the information is conveyed to the user via the Text-to-speech (TTS) engine of the mobile application. The screens are designed such that it is convenient for a visually impaired person to touch and operate. They also contain pictures for giving it an aesthetic look to surrounding people and in case we extend the system for sighted persons in future. All the information stored in the app database was provided by the museum authorities and mimics the information displayed on the information boards attached to the exhibit or exhibition.

On starting the application, the app logo is displayed (not shown). As the user enters an exhibition, the first screen pops up with an audio message conveying the name of the exhibition. It has a ‘learn more’ button and a small picture of the exhibition, both of which can be touched to know more information about the exhibition. While navigating in an exhibition, the middle screen is displayed when the user is near an exhibit. Again, the written information is spoken to the user and the ‘learn more’ button can be touched for a detailed description of the exhibit. The screen remains till the user is near the exhibit. The rightmost screen is the standby screen which is displayed when the user is not near any exhibit. It contains the status of the bluetooth connection with the user module and options for social networking, both of which can be accessed with a screen reader. It also conveys auditory information to navigate further which include any turn to take and the number of steps to travel. If the user deviates from the path during any stage of the application, a warning is given. Moreover, when any screen pops up, a vibration alert is also given.

## 3. USER EVALUATION

**Study Design:** The system was installed in one of the smaller exhibitions located on floor 2 of NSC called Pre-Historic Life. It consists of a narrow main track approx. 60m of length and some smaller paths originating from it and leading to the exhibits. There are 7 large and 2 small groups of exhibits on the track. A total of 16 wall modules were deployed, 7 for navigation, at an interval of about 8m and additional 9 near the exhibits for precise localization.

The male study participant was selected from a NGO in Delhi. He had basic English literacy and adequate knowledge of using a mobile phone. He was fully blind from birth and possessed no other impairment. He used cane and would typically ask for directions from sighted individuals while navigating. The participant had never visited any public museum alone and this was his first visit to NSC.

**Qualitative evaluation:** The participant was given a demonstration of the system, trained for approx. 45 min in a separate conference room of the museum and was brought to the entrance of the exhibition. He was told to navigate in the exhibition using his cane and the system. The participant identified and gained information about the exhibits as and when he desired. Upon satisfaction, he navigated out through the exit. The process lasted for approx. 20 min, following which a 15 min interview was taken.

The user was able to effectively understand the usage of the device and successfully navigate in the exhibition as shown in Figure 1. He eagerly expressed been able to identify majority of the exhibits and find out more information about them. However, it was difficult for him to distinguish some of the closely located exhibits. We realized that a few wall modules were located very close to each other, and since the range of the modules is large (8 m), this caused interference. We propose to decrease the range of the wall modules installed close to the exhibits using carefully designed rapid prototyped covers.

*“The museum is very informative and the application instructions were appropriate to learn about the exhibits. This would be very educational for (blind) school students.”*

The user was happy with the carefully designed stages of the application and appreciated its features.

*“The application instructed me to come back to the main track every time I deviated to closely observe an exhibit. It was easy to navigate independently within the crowd.”*

*“I don’t want to know about every exhibit... Some of them appeal to me more than others and I can choose to hear more about them by pressing ‘Learn more’ button...”*

The instructions were clear and audible. The user was able to control the volume to suit according to the crowd. He expressed however, that controlling volume takes time and if possible, would like the application to automatically set the volume based on the surrounding noise.

## 4. CONCLUSIONS

In this paper, we reported the results from pilot evaluation of an unobtrusive and efficient indoor navigation system for visually impaired in a public museum in India. The results indicated that the system is usable and useful but can still be improved. Future work includes long-term deployment and field testing with more users.

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