BlindNavi: A Navigation App for the Visually Impaired Smartphone User

Chen, Hsuan-Eng
Design Information & Thinking Lab, Industrial Design Dept., National Taiwan University of Science & Technology, No.43, Sec. 4, Keelung Rd., Da'an Dist., Taipei 106, Taiwan (R.O.C.)
detsub1942@hotmail.com

Chen, Chien-Hsing
Design Information & Thinking Lab, Industrial Design Dept., National Taiwan University of Science & Technology, No.43, Sec. 4, Keelung Rd., Da'an Dist., Taipei 106, Taiwan (R.O.C.)
aprilcc45@gmail.com

Lin, Yi-Ying
Innovative User Interface Lab, Digital Content and Technologies Dept., National ChengChi University, No.64, Sec. 2, Zhinan Rd., Wenshan Dist., Taipei City 11605, Taiwan (R.O.C.)
yummyummy55@gmail.com

Wang, I-Fang
Innovative User Interface Lab, Digital Content and Technologies Dept., National ChengChi University, No.64, Sec. 2, Zhinan Rd., Wenshan Dist., Taipei City 11605, Taiwan (R.O.C.)
iff.wang@gmail.com

ACM Classification Keywords
H.5.2. User Interfaces: User-centered design.

CHI'15 Extended Abstracts, Apr 18-23, 2015, Seoul, Republic of Korea
ACM 978-1-4503-3146-3/15/04.
http://dx.doi.org/10.1145/2702613.2726953

Abstract
These days, many of us frequently use mobile apps to help us navigate. However, these apps with touch screens are not user-friendly for visually impaired people who are eager to be able to leave their homes independently. Moreover, the most widely used apps are not specially made for the visually impaired, so they create much confusion and result in a problematic user experience. The main purpose of this research is to provide a new mobility-aid solution in the form of a navigation app that remembers meaningful information over the journey and makes the trip safer and smoother. Unlike those applications that provide visual guides, we want to refer to the way blind people recognize and remember their route, and provide multi-sensory messages combining familiar reference points that they have learned from Orientation and Mobility (O&M) training. "BlindNavi" is an app prototype with a 3-step simple search, flat flow design, voice feedback consisting of multi-sensory clues, combined with micro-location technology, to assist visually impaired people leave their homes and safely explore the outside world on their own.

Author Keywords
Blind; Visually Impaired; Navigation; Smartphone; Accessibility; Orientation and Mobility; User Experience; Micro-location

Introduction
Research Background & Purpose (Figure 1)
With the current popularity of smartphone technologies, many of us commonly use a navigation app in our daily

Figure 1. Research Background & Purpose

Figure 2. Participant Observation

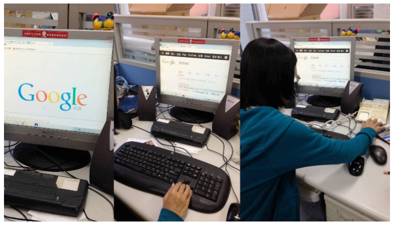

Figure 3. In-depth Interview

life. However, the navigation apps with visual feedback and touch-based user interface are not applicable for the visually impaired. The visual impaired tend to simplify a complex itinerary into a straightforward process of moving between spots. We want to provide micro-location information through iBeacon while navigating. Features of short distance accurate transmission make it suitable for walking navigation. The purpose of this research is to create an app to pave a safe way for the visually impaired smartphone user. By enhancing the cognition of their living environment, the ability to move autonomously will improve as well. Ultimately, BlindNavi will allow the visually impaired user to further explore the world on their own and enjoy increased independence.

Related work

According to relevant studies, with proper training the visually impaired can build a mental map in almost the same way as sighted people can. However, abstract concepts like numbers, distance, or colors are not easy for them to understand.[1] Research also shows that "itinerary descriptions" is the best way to guide a visually impaired person because it is part of their O&M training. Gaunet [2] explains that the visually impaired need different kinds of information than a sighted person does in a corresponding scenario: 1) Straight road section. 2) Intersection area. 3) Crossing the roads. 4) Walk in progress: landmarks, special environment clues. It also recommended that the guiding information provided by a navigation system should be in 5 meters. Providing notification at the best timing and continuous reminders are both necessary. Unlike sighted people, the visually impaired rely on advance planning before going out.[3] Their hands, ears, and attention are occupied and concentrating hard while they are actually walking on the street. As a result, both the user interface and function design should be simple so it will not distract users.

Navigation notifications en route can be divided into two parts: voice or vibration. With regard to voice notification, ISAS [4] uses open-ear headphones to provide spatialized POIs along the route. Trekker is a GPS-based handheld device that broadcasts messages by itself without headphones. As for vibration notification, GoBraille [5] combines Braille devices and smartphones to provide information on public transportation to the visually impaired. PocketNavigator [6] uses a combination of different vibration lengths to tell the user which way to go even when the phone is in his/her pocket. NavRadar [7] divides the journey into only two directions, present direction and desired direction with one and two vibrations respectively. In addition, the most common way of outdoor positioning is GPS, for example, BlindSquare (http://blindsquare.com/), NaviRadar, and Trekker. When inside a building, Listen2dRoom [8] uses image recognition, and INSIGHT [9] serves as a navigation system via Bluetooth and RFID technology.

Preliminary Research and Survey

In order to analyze the behavior of visually impaired users, we conducted nine interviews (eight with visually impaired people, and one with a sighted O&M Instructor) with six smartphone users included (Figure 2). Each of them was asked about their experience of using a smartphone or navigation-relevant product and they were asked to outline their habits (Figure 3). We found that younger individuals are more comfortable using smartphones than older individuals are. For participant observation, we followed two of our interviewees on the road to observe a real-time situation using navigation. An O&M instructor also provided her nine years' of expertise in the field by explaining how the visually impaired filter information when walking. To simulate the experience of the visually impaired, we covered our eyes during the interview with the O&M instructor.

Figure 4. Four main functions

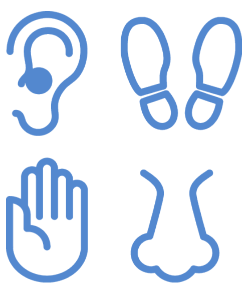

Figure 5. Multi-sensory Clues

Research Findings

THE PREPARATION AT HOME

1) The visually impaired always go out with a very specific purpose (e.g. going to school/work, shopping for daily goods). 2) They prefer not going to unfamiliar places without company. 3) If a visually impaired person is going somewhere new, they tend to call and ask for directions, take someone with them, or carry the address and phone number of the destination in case they need to ask for help from sighted people along the way. 4) Cell phone/ White cane/ Weather information are the must have items when they go out.

ACTUALLY ON THE ROAD

Some facts we discovered while on the road include the following: 1) The route with the least transfer time is preferred; 2) Some visually impaired people prefer to ask for directions while walking to ensure they are on the right path; 3) They prefer to choose an MRT station as a meet up location; 4) Most of the visually impaired check their current location by GPS or ask a pedestrian once they feel lost; 5) The apps they frequently use for communication are Line or Facebook, and for navigation purposes they use Apple maps, bus information, and GPS self-locating.

EXACTLY WHAT KIND OF INFORMATION DO THEY HAVE IN MIND?

Interviewees were asked to describe how to walk from location A (MRT station) to location B (McDonald's) to another visually impaired person. A lot of multi-sensory clues appear in the result:

Exit #1→ Turn right after a few steps→ Cross an ally, Listen to make sure there are no cars→ Go straight, walk alongside the wall to ensure you are heading straight forward→ Pass a bakery shop, you will smell the sweet bread first→ McDonald's is right next to it→ 7-11 is next to McDonald's, if you hear the doorbell of 7-11, it means you have gone too far.

AFTER GOING HOME

The visually impaired love to share their walking experiences with their friends. There are several visually impaired exclusive online forums and chat groups where they can ask/answer any kinds of questions or share their own experience.

Initial Design

According to our interviews and observation, we conclude our design directions as follows (Figure 4):

Multi-Sensory Navigation Message

Each navigating description includes three parts. First, the location name; it is displayed as road intersections, lanes, bus/MRT stations or stops. Second, the environmental description; it is delivered by the unique feature of BlindNavi that provides detailed clues to the user including those felt by touch, hear, smell, or step (Figure 5). It can be auditory, olfactory, or tactile clues like car noise, a doorbell, or the smell of food. Sighted people often ignore these clues but it is the key point of successful "multi-sensory" clue navigation content. Last, corresponding actions for the users such as making turns or going straight ahead.

Most navigating instructions are designed for sighted people, for example, "turn right after 500m". Obviously, the visually impaired do not perceive the same distance in the same way because they cannot see. Research shows that it is more difficult for them to form abstract concepts such as numbers. We need to rephrase this "sighted" navigation content to "visually impaired" navigation content. In this case, "Turn right after 500m" should be "Turn right after two blocks, you will hear a doorbell".

User-Generated Content & Sharing Mechanism

BlindNavi automatically saves the route the user has walked so he/she can add it their own memo and have detailed descriptions of every spot on the route and they can share it. Recording the audio markers from actual

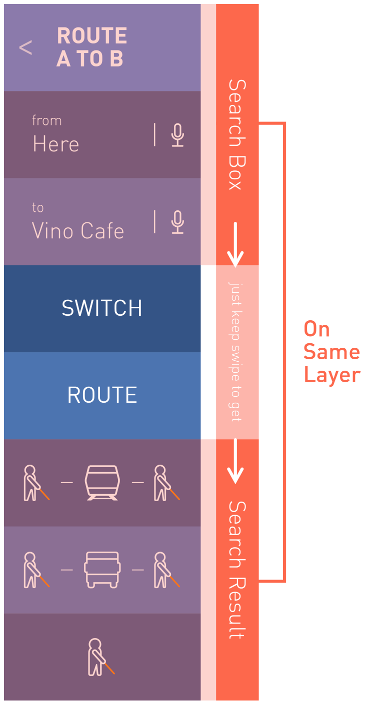

Figure 6. Flat information architecture

Figure 7. Gesture Shortcut to activate

locations may be another part of user-generated content/annotation of routes.

Flat Information Architecture (Figure 6).
The blind use a touch-based interactive screen by VoiceOver or a built-in screen reader for iPhone. The user can swipe right or left to move the cursor, it reads the content or function of each button. Based on this usage pattern, we decided that the information architecture of the app should be as flat as possible. Building too many layers would only confuse users. So the user is able to examine all search results on the same screen without switching between different app layers, and he/she can start another search anytime

Multimodal Interaction Design
Voice message, vibration, and gesture are all possible options. Three kinds of notification will be offered to the user while BlindNavi navigates. Short vibration means keep going straight; long vibration means turn right or left; continuous vibration means not on the right path. Each notification also comes with a corresponding voice message.

Gesture Shortcuts
In BlindNavi, the "Where Am I?" function can be activated simply by shaking the phone (Figure 7). It tells you the current address, the surroundings at each clock position, and the nearest bus or MRT station.

High Contrast Visual Design
The visual design should be simple, with very large text, and high contrast colors. We chose four bright and distinguished colors for each function, e.g. blue for "Route A to B". Every screen under "Route A to B" is blue. Thus, the user always knows where he/she is simply by differentiating between the colors.

Micro-location Information
As mentioned previously, the visually impaired tend to simplify a complex itinerary into a straightforward process of moving between spots. Micro-location information saved in iBeacons is sent to users when they walk by them. In comparison to traditional GPS based navigation, iBeacon transmission distance is shorter (2-70 meters). The little deviation is more suitable for walking navigation. Plus, iBeacon is not only a location tag, but potentially become a business model (Figure 8). Recently, retail shops like Macy's, American Eagle, Lord & Taylor, even MLB Stadium, push highly contextual, hyper-local, meaningful messages and advertisements notifications to customers through iBeacons. Hopefully stores will voluntarily adopt the iBeacon tag as a free advertisement channel while the map data is becoming more complete.

Low-Fidelity Prototype and User Testing
In order to evaluate BlindNavi, we conducted four interface usability studies and three on-road navigation tests with four blind people. Two of the four were totally blind, one had only light perception, and one was amblyopia, all of them were familiar with the use of iPhone and VoiceOver (Figures 9 & 10).

Interface usability studies
After a brief explanation of BlindNavi, users were able to use the app freely on iPhone 5s, and then were asked to use BlindNavi to search for routing plans.

On-road navigation testing
The route was from Taiwan Normal University of Technology to a transfer-needed cafe shop. Stores, traffic lights, road intersections, and large landmarks on this route were equipped with iBeacons; whenever the user passed by these reference points, BlindNavi gave both voice and vibration messages to inform the user of the next action he/she should take. For example, "Place A, a Cabins Waffles House at 2 o'clock, please continue straight." By informing users about stores around them, we hope the visually impaired people can refer to the sound and smell of a particular store, not only to further explore the environment but to confirm their position throughout the trip. The whole journey took 20 minutes

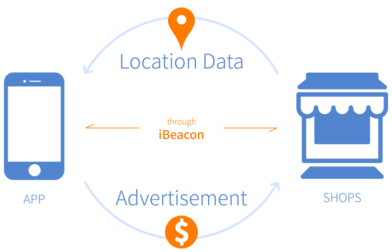

Figure 8. Business model from iBeacon

Figures 9 & 10. Prototype user testing

walking to the MRT station, 10 minutes ride on the MRT, and 20 minutes from the MRT station to the destination coffee shop. Afterwards, we conducted a deep interview in that cafe. The average completion time was 58 minutes.

Feedback of Interface usability studies

At first we assumed the users would prefer voice entry, but all testers replied that voice entry could be unreliable in a noisy environment, and it took too much effort to correct mistakes. As a result, text entry should be kept as well. Two users wished to enter phone numbers to find other information because a phone number is easier to memorize and input. Destination address from Function 1, ”Find Address and Number”, auto-fills the destination field in Function 2, ”Route A to B”, to give users quick access to route planning. Two people suggested the current GPS position be auto-filled to the starting point as both Apple Maps and Google Maps do. In most situations, they might not have to waste time doing any input. Besides, one frequent Apple Map user suggested BlindNavi should also put the user’s current location in the center of the screen even when the screen is locked for the user to check their position whenever necessary. Three users wished the ”Where am I?” function could be easily reached by “some sort of way” or by shaking the phone quickly, at any time while walking. The “Where am I?” function should jump out from the interface and be reached by gestures or hard buttons at will instead. One participant hoped the “Where am I?” function would be able to directly navigate in case the user panics when he/she is lost.

Feedback on On-road navigation testing

Our voice feedback went through three iterations. The first version consisted of "landmark, multi-sensory description of the area, action”. However, the participant replied that he was distracted by so much content, and did not know what to do. Therefore, we changed it to “landmark, action, multi-sensory description” in the second experiment. The user still had the same problem, even though we had already brought “action” forward, he felt distracted due to the verbose description: “What I want to know first, is the next step I should take!” Thus, “action” was brought to the first, and then “landmark”, and abridged “description”, and it worked much more smoothly.

One participant said the clock position we had for navigation was very helpful. It also tallied with their O&M training experience. Two users suggested that cornering should be informed previously, and the turning moment was needed positively by all participants. Two participants said the vibration was not obvious; this may be because the phone was in their pocket instead of being held in their hand while walking. One user recommended the difference would be more significant if the vibration was changed from vibration times to duration.

Neither Apple Maps nor Google Maps alerts users when to cross the street. However, users think this is useful. Notification of continuing straight was embraced by all participants; they thought it would not only confirm their position, but reassure them that the system had not crashed. In the scenario of getting lost, two participants suggested instant route correction and re-planning are needed. One said the Apple Map re-route function without informing the user is unfriendly to visually impaired users. Interestingly, at first we thought details of the trip like barriers, road construction, or motorcycle parking area would be helpful. However, some participants became anxious about the environment; the awareness of danger could not help them avoid it. This kind of reminder was designed to reduce the short memory burden but caused mental stress instead. However, one day when BlindNavi is able to tell the exact position of danger, this kind of information will certainly be more helpful. All the above issues are worthy of discussion.

Figure 11. In navigation mode, indicating directions should be the first thing mentioned in the navigation message.

Overall evaluation from testing

In general, all participants were looking forward to using BlindNavi and had the following advice: 1) Integrate it with the bus dynamic system; 2) memorize searching history so users do not have to go over it all again; 3) if a user can save favorite addresses that would save a lot of trouble; 4) add an emergency call button (911...etc.); 5) any location ever mentioned in the route can be used for a new destination directly; 6) move "Public transportation around" and "Where am I?" to the top level of BlindNavi; 7) add a function "Search points of interests"; 8) add "Landmarks" category; 9) add gesture design to the function "Where am I?".

Some of the advice will be adopted and tested in the next experiment.

Conclusion

We conclude with some design guidelines for a future app design: 1) Avoid adding the app hierarchy, search results should be displayed directly on the same page instead of jumping to another; 2) itinerary descriptions are the best way to guide users; 3) depending on the situation, voice and text entry are two important input methods; 4) for users who go out every day, detailed information is not always better. Instead, the information should be useful content of a proper length; 5) numbers and directions (East, West, North, and South) are too abstract for the visually impaired to understand. Clock position is a better way to describe it; 6) in navigation mode (Figure 11), indicating directions should be the first thing mentioned in the navigation message. Through the overall UX design process, we conducted several in-depth interviews, participant observation, and experiment to explore the problem and needs of visually impaired people when they go out. After a number of iterations of prototyping, our participants were all grateful to say that BlindNavi takes their needs into account and makes their trip smoother. We hope to build a new connection between the visually impaired community and the colorful world by taking such deep research and design procedures to fruition. This is the true meaning of "crossings".

Acknowledgement

This study was partially supported by the National Science Council, Taiwan, under grant MOST103-2218-E-004-002 and MOST103-2218-E-002-025-MY3.

References

[1] Z. Cattaneo, T. Vecchi, C. Cornoldi, I. Mammarella, D. Bonino, E. Ricciardi, and P. Pietrini, "Imagery and spatial processes in blindness and visual impairment," Neuroscience and Biobehavioral Reviews, vol. 32. pp. 1346–1360, 2008.

[2] F. Gaunet and X. Briffault, "Exploring the Functional Specifications of a Localized Wayfinding Verbal Aid for Blind Pedestrians: Simple and Structured Urban Areas," Human-Computer Interaction, vol. 20. pp. 267–314, 2005.

[3] H. Ye, M. Malu, U. Oh, and L. Findlater, "Current and future mobile and wearable device use by people with visual impairments," Proc. 32nd Annu. ACM Conf. Hum. factors Comput. Syst. - CHI '14, pp. 3123–3132, 2014.

[4] J. R. Blum, M. Bouchard, and J. R. Cooperstock, "What's around me? Spatialized audio augmented reality for blind users with a smartphone," in Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, 2012, vol. 104 LNICST, pp. 49–62.

[5] S. Azenkot, S. Prasain, A. Borning, E. Fortuna, R. E. Ladner, and J. O. Wobbrock, "Enhancing Independence and Safety for Blind and Deaf-Blind Public Transit Riders," in Proceedings of the 2011 annual conference on Human factors in computing systems - CHI '11, 2011, pp. 3247–3256.

[6] M. Pielot, B. Poppinga, W. Heuten, and S. Boll, "PocketNavigator□: Studying Tactile Navigation Systems," in CHI '12, 2012, pp. 3131–3139.

[7] E. Rukzio and R. Hardy, "NaviRadar□: A Tactile Information Display for Pedestrian Navigation," pp. 293–302, 2011.

[8] M. Jeon and N. Nazneen, "Listen2dRoom: helping blind individuals understand room layouts," CHI'12 Ext. …, pp. 1577–1582, 2012.

[9] A. Ganz, S. R. Gandhi, C. Wilson, and G. Mullett, "INSIGHT: RFID and Bluetooth enabled automated space for the blind and visually impaired," in 2010 Annual International Conference of the IEEE Engineering in Medicine and Biology Society, EMBC'10, 2010, pp. 331–334.