International Journal of Interactive Digital Media, Vol. 2(1), ISSN 2289-4098, e-ISSN 2289-4101, www.ijidm.org

B-DiNAMA: Liberating the visually impaired users

Masitah Ghazali and Sangeetha Pulanisamy

Abstract—Navigation is extremely difficult for the visually impaired users. In this paper, we describe an Android application, the Direction Navigation Assistant Mobile Application (B-DiNAMA), as our initial work in liberating the visually impaired users to navigate through the neighbourhood conveniently including trivial locations and improve their accessibility via smart phones. B-DiNAMA makes full use of the speech recognition technology to indicate the current position of the user and the destination the user wishes to go by allowing the map to be preprogrammed accordingly. B-DiNAMA in return gives direction (via audio output) to the user and the directions are updated in every 5 meters as the user started walking. This paper highlights the lessons learned from the pilot user study, which should be significant especially in improving the application. The results of the pilot user study shows that the application is proven to be interactive, useful and efficient as the users used it.

Index Terms—Speech recognition; navigation; blind; human-computer interaction;

1 Introduction

To date, navigation applications in Android mobile phone were only customized and designed for normal people. They are able to key in the location that they wanted to travel to and able to observe the screen for the directions to the specified location. But, what about the people who are visually impaired?How can we liberate them? Mobile navigation for the blind is extremely important as it really helps them to track where they are currently at and where to go. There are some developments that can help for the visually impaired people's mobile phone accessibility, which are Google I/O 2011(a braille PDA or cell phone) [1], Vlingo(Virtual Assistant that turns words into action) [2] and many others. Among of the current limitations of the braille PDA are; maps are not updated frequently, and expensive, whereas the limitations of Vlingo are; less efficientand needs fast Internet connection. The features of this Direction Navigation Assistant Mobile Application for Blind using Google Map on Android Platform (B-DiNAMA) are to help the visually impaired people by giving instructions using speech output, finding particular destination and finding current location using speech input.

In this paper, we present a study of B-DiNAMA, which could be seen as a foray in liberating the visual impaired people. The following section of the paper presents the background and related work. The next section outlines the design and the development of B-DiNAMA followed by the pilot user study. Lessons learned will be discussed in the subsequent section, followed by a conclusion.

- *M. Ghazali is with the Software Engineering Department, UniversitiTeknologi Malaysia, Malaysia, Johor 81310. E-mail: masitah@utm.my*
- *S. Pulanisamy is with Altera Corporation Penang, Malaysia. E-mail: sangeetha.pulanisamy@yahoo.com.*

2 Background and Related Work

2.1 Visually Impaired Users

Visual impairment including blindness means impairment in vision that, even with correction, adversely affects a person's performance [3]. The term is divided into two, which are partial sight and blindness. This impairment refers to abnormality of the eyes, the optic nerve or the visual centre for the brain resulting in decreased visual acuity. People with visual impairments are identified as those with a corrected visual acuity of 20/70 or less in the better eye or field restriction of less than 20 degrees at its widest point or identified as cortically visually impaired and functioning at the definition of legal blindness [3].

For the purpose of the development, the visually impaired users' requirements were obtained from a group of blind people at St. Nicholas Blind School in Penang. A short interview session was conducted in order to obtain their requirements and comments on the application that was about to be developed. Four blind students have been randomly selected and asked to answer a few questions regarding the application. Most of them answered that they were satisfied with the proposed application and have met their requirements on navigating from one place to another place and also get to know where they are currently at by using speech input and output. They have also given some suggestions like the application should detect the obstacles in front of them; the speech output should be clear and so on. The application has been developed based on most of their requirements and comments.

2.2 Visually Impaired Assistive Technologies

Assistive technologies enable people with disabilities to accomplish daily living tasks, assist them in communication, education, work or recreation activities, in essence, help them achieve greater independence and enhance their quality of life. Assistive technology services support people with disabilities to help them select, acquire, or use adaptive devices. Such services include functional evaluations, training on devices, product demonstration, mobility and equipment purchasing or leasing [4].

Navigation actually refers to the purposeful process involved in travelling from one place to another, by using mobility skills and orientation in the environment to a particular destination. It is divided into three methods, which are position-based navigation, velocity-based navigation and acceleration-based navigation [4]. Position-based navigation depends on external signals within the environment, such as landmarks, showing the traveler's position and orientation. Velocity-based navigation depends on external and internal signals showing to the traveler their current position by projecting course and speed from the past location. While acceleration-based navigation relies on both the traveler's linear and rotary accelerations to acquire information on displacement and heading change from the origin.

Products that help mobility impaired persons move within their environment and give them independence in personal transportation. It includes standing/walking aids, transfer aids, stair lifts, walkers, scooters, wheelchairs and three-wheeled chairs, adapted bikes and Trikes, car seats/bed, stretchers, patient chairs, ramps, recliners, strollers, travel chairs, wheelchair trays, driving controls, seat belts, vehicle conversions, patient and wheelchair lifts, wheelchair loaders/carriers, wheelchair restraint systems, and so on [3]. For a visually impaired people, the ability to orientate and navigate is an important skill that is used to experience and interact with the environment, to make social contact with different people, undertake daily routines and to maintain independent mobility without the help of other people.

There are actually many existing navigation applications for the visually impaired people. Its main functionality is to help them to navigate from one place to another place conveniently. For instance, there are Loadstone GPS [5], Wayfinder Access [6] and Victor Trekker [7]. Both Loadstone GPS and Wayfinder Access can be installed on Symbian phones only with purchase, while for Viktor Trekker, it comes on its own hardware device, which uses Windows Mobile Pocket PC as its platform and needs to be purchased at some cost. The maps used in these applications are not updated while on use, and cannot be manipulated and developed. Common features available are; allowing the user to know the current position, informing points of interest nearby based on the current user position, and provide directions to the chosen point of interest.

The main drawback of the existing applications is, they only recognized the points of interest nearby and the map provided cannot be manipulated to suit the user. B-DiNAMA is developed to overcome this limitation by enabling the visually impaired users to also go to trivial location, such from his/her current location to the foyer, or canteen, or a bus stop. And with the popular usage of Android based smart phones [8], B-DiNAMA is developed on the Android platform to reach out to more visually impaired users at no cost.

3 B-DiNAMA Design and Development

The process application system design includes the processes of user interface design, location database, mapping, navigation and positioning. First and foremost, the user interface (UI) design was operated on a typical handheld smart phone. The UI handles the interaction between the user and the application. The interaction was made to prompt the user of available options using speech output to inform the user of their current location. The location database was used to keep all the data of locations for all its entries. It is searchable using the places' names. The mapping process is used to map the estimated position onto the particular location. Other than that, navigation process was used to direct the user from their current location to their destination along an ideal path. Last but not the least; the positioning process makes use of GPS technology in order to find out position the satellite to determine the user's position required. It requiresan open space to determine the location's position. Fig. 1 shows the overall system design block diagram.

In order to use the B-DiNAMA, the user has to make

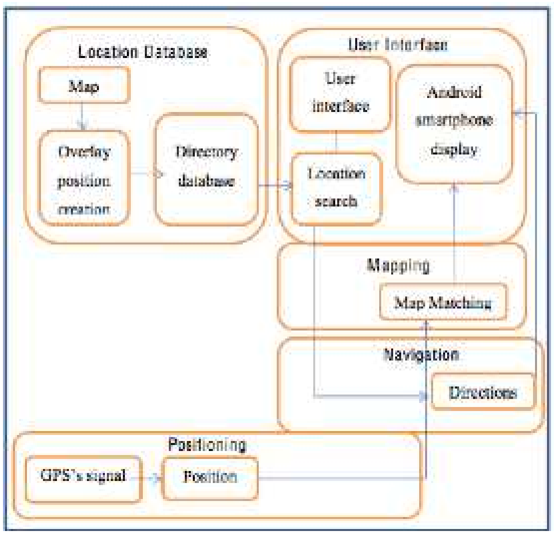


Fig. 1. Overall system design block diagram

sure the GPS and mobile network or Wi-Fi are activated to start using the application. The user has to activate the application first before using the application's functions. When user inputs the current location command, the system will determine the position of the current location of the user by performing geocoding and reverse geocoding to display and read out the longitude, latitude and street address. When the user inputs destination command, the users have to speak out which destination they wanted to go to. The system will determine the initial destination as per user's choice and update the destination overlay marker to that particular destination.

The system will determine the position of the current location of the user by performing geocoding to display the longitude and latitude. The system will update the current overlay marker as the user moves by performing an event driven programming. The overlay marker is updated every 5 meters as the user walks from the current location. The system will perform programmed directions algorithm after the user has determined which destination to go. It is triggered based on the current overlay marker falls on the designated area radius that have been pre-programed. Different area radius gives out different directions based on the map’s layout. The system will display the map and tells the user of the directions to go to the particular destination using speech output. User can close the application as they wish. Fig. 2 illustrates the flow chart of the B-DiNAMA application.

The UI of B-DiNAMA has been kept as minimal as possible as it won’t be the most important features for the visually impaired users. Fig. 3a shows the splash screen of the application. This interface will appear upon execution of the application. Fig. 3b shows the main interface of the application. The user can choose between two options given, which are Find Current Location or Find Destination to Go. In order to open the speech recognition synthesizer, user has to click thebutton above. After they have spoken out the option they wanted to choose, it will be displayed in the text box. Then, the user has to tap the screen in order to move to the next activity.

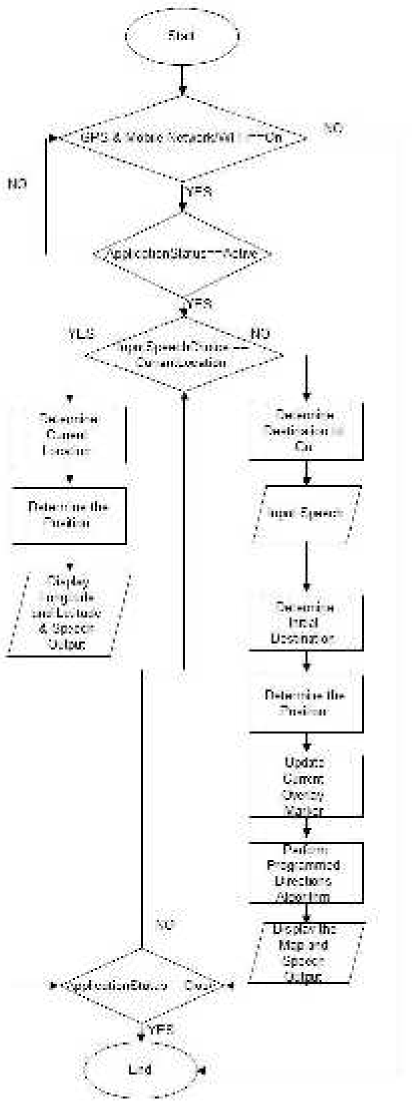


Fig. 2. B-DiNAMA flow chart

Fig. 4a shows the interface when the user has selected the Find Destination to go option. The concept is same like the main interface’s concept. In order to open thespeech recognition synthesizer, user has to click the button above. After they have spoken out which destination location name they wanted to go, it will be displayed in the text box. Then, the user has to tap the screen in order the system plots the destination overlay marker on the map. Fig. 4b shows the example of interface shows when user started walking from the initial position. The current overlay marker gets updated every 5 meters. As the overlay marker triggers the specified area radius, the system speaks out the direction until reach destination.

Fig. 3a Splash screen

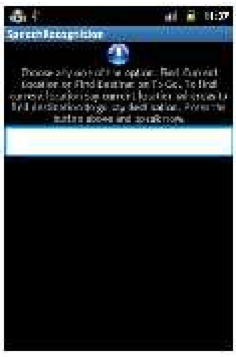


Fig. 3b Main interface

Fig. 5a shows the interface when the user has selected the Current Location. In order to listen to current location, the user has to click the button on the top. The system will speak out the coordinates and street address. After the system finishes speaking, in order to direct to the sub menu activity, the user have to wait as there is a timer

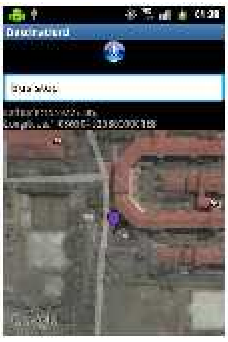


Fig. 4a Choose destination (destination overlay marker)

Fig. 4b Choose destination (current overlay marker)

handler set for 35 seconds. Fig. 5b shows the interface where the system prompts the user whether to exit the application or continue. In order to open the speech recognition synthesizer, the user has to press the button above. If the user chooses continue, it will be directed to the main interface of the application. If the user chooses exit application, the application will exit.

The application development wasinitialised after the completion of the design activities. The development phase mainly involves coding to create the application. JDK 6(Java Development Kit), which is the compiler for Eclipse IDE for Java Developers was used. For the Eclipse IDE to run, it requiresan Android SDK and ADT

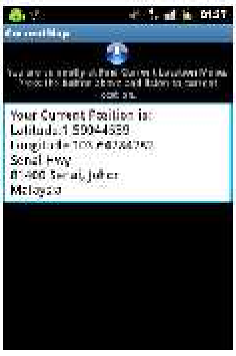


Fig. 5a Choose current location interface

Fig. 5b Sub menu interface

(Android plugin for Eclipse). The coding was conducted under Windows 7 Home Edition operating system. This phase will ensure that B-DiNAMA mobile application exist and functions accordingly with the user's requirement fulfillment.

5 B-DiNAMA Pilot User Study

This pilot user study has been carried out to gather the empirical data regarding the usefulness, ease of use, and user satisfaction associated with the application. Several different kinds of data have been collected and interpreted with respect to possible design changes. In addition to gathering formative evaluation results, users' experiences may vary with the application.

5.1 Method

Usability evaluation method using live version of B-DiNAMA mobile application installed on a smart phone was conducted as the pilot user study. An on site usability evaluation was performed at one location, which was at College 9, UTM. Two tests were conducted using different blind people. Each individual session lasted approximately 15 minutes.

5.2 Participants

Two visually impaired users participated in the pilot user study. Both are male, aged 26 and 29 from JabatanKebajikanMasyarakat (JKM) Johor Bahru. These two participants were recommended by the head of the Johor Bahru division from the JKM.

5.3 Measures

Usability evaluation materials have been developed before carrying out the user study to support the activities, which are:

1. *User background survey.* The background survey contains all the information about the users, such as their name, age and level of their visual imparity.
2. *Task instructions*. "Exploratory" form of scenario testing have been done, where users are provided with an actor and usage context and then asked to pursue a goal with the system while thinking aloud about their goals, plans and reactions. A set of general instructions has been given to the users.
3. *Task data forms*. Track of scenario start and stop times have been recorded, a few verbal comments and noted any errors that are made.
4. *User reaction survey*. This survey is used to assess reactions to the prototype once the scenario has been attempted. It was divided into two components: specific Likert scales that are tied to the features highlighted, and a small set of open ended question that gathered more qualitative reactions. A small interview session was conducted to write down in the user reaction survey form.

A camera and a video camera were used to capture the participants and their choices while testing the application. The session captured each participant's navigational choices, task completion rates, comments, overall satisfaction ratings, questions and feedbacks.

5.4 Procedure

The session began by filling in the informed consent form and background survey and answering a few questions regarding the procedures.

It started with the general instructions, emphasized and answered questions about the think-aloud process. It was to ensure that how they will signal the start/stop of the task. Then, the scenario storyline was read aloud, and set the prototype in the starting state, with GPS and Wi-Fi/mobile network switched on. The user was reminded to think out loud when doing the task, then observed what he or she does, and wrote down verbal comments. Start-stop time and errors for these episodes were carefully recorded. After all tasks were completed, the participants were interviewed to complete the user reaction survey. Then the users were debriefed about what have been expected to find, how findings were to be used, and answer questions that have been posted by them. Fig. 6 shows the participants testing out the B-DiNAMA.

Test participants must attempt to complete all following tasks:

- Task 1: Find current location using speech input
- Task 2: Find destination to go using speech input
- Task 3: Clicking button

- Task 4: On tap screen
- Task 5: Activate application
- Task 6: Close application

Task instructions were given out before the evaluation. Each participant was then asked to pursue a goal with the system while thinking aloud about their goals, plans and reactions.

5.5 Data Collection

Fig. 6 Participants tested out B-DiNAMA overlooking by a researcher

The task data forms were filled out to keep track of scenario start and stop times, verbal comments and noted any errors that are made. After each task, the participants were asked to rate the interface on a 5-point Likert Scale with measures ranging from Strongly Disagree to Strongly Agree. The participants were asked to rate the application overall by using a 5-point Likert scale (Strongly Disagree to Strongly Agree) for six subjective measures, which are:

- Ease of use
- How quickly participant find the destination they wanted
- How quickly participant find the current location
- Learn ability – how easy it would be for most users to learn this application
- Frequency of use
- How helpful is the application

In addition, the participants were asked of the following overall open-ended questions:

- What the participant liked most in this application
- What the participant liked least in this application
- Recommendations for improvement

5.5 Results

This section presents all related results based on the pilot user study. Both participants successfully performed all six assigned tasks.

1. *Tasks Completion* After the evaluation the participants rated the ease or difficulty ofcompleting each task based on the following two factors:
   - o Able to navigate through the application easily
   - o Browse through the application, able to keep track of which section of the application they are currently at

The 5-point rating scale ranged from 1 (Strongly disagree) to 5 (Strongly agree). Table 1 shows the ratings of each task based on the two factors mentioned above. Both participants found task three (click button) as the hardest to navigate (with1.5 mean rating) and found task four (on tap screen) and task five (activate application) as the easiest to navigate (with 5.0 mean rating). Meanwhile, both were full aware of the state of the application while doing task 4 (on tap screen) and 6 (close application) with mean rating 5.0, but unsure about the state of application while doing task 2 (find destination to go) and task 3 (click button) with mean rating 2.0.

TABLE 1. MEAN TASK RATINGS

Task	Ease of navigation	Know of current section
#1 Find current location	3.5	4.0
#2 Find destination to go	2.0	2.0
#3 Click button	1.5	2.0
#4 On tap screen	5.0	5.0
#5 Activate application	5.0	4.0
#6 Close application	4.5	5.0

2. *Time Spent on Tasks* Task 2 which requires the participants to find the destination to go took the longest time to complete (mean = 84.5 seconds) as compared to the rest of other tasks. However, completion times ranged from 120 (approximately 2 minutes) to 143 (more than 2 minutes) per individual. Table 2 illustrates the results.

TABLE 2. TIME SPENT ON TASKS

Participant / Task	P1 (sec)	P2 (sec)	Average Time Spent on Task (sec)
#1	39	29.2	34.1
#2	90	79	84.5
#3	4	3	3.5
#4	4	3.7	3.85
#5	3	2	2.5
#6	3.4	3.3	3.35
Total	143.4	120.2	

3. *Errors* A number of errors participants made were captured while trying to complete the task scenarios. No errors made for tasks 3, 4, 5 and 6. One error was made for task 1, and six for task 2.

4. *Overall Metrics* After task session completion, participants rated the site for six overall measures as mentioned in section E. Both participants agreed (i.e., agree or strongly agree) that the application was easy to use. They both agreed they would use the application frequently and thought the application was helpful. See Table 3 below for post-pilot user study questionnaire.

TABLE 3. POST PILOT USER STUDY QUESTIONNAIRE

Participant (rate) / Questionnaire	P1	P2	Average Time Spent on Task (sec)
Thought application was easy to use	3	4	3.5
Thought how quickly they find the destination to go	2	2	2.0
Thought how quickly they find current location	4	4	4.0
Thought they would learn to use application quickly	2	2	2.0
Would use the application quickly	3	5	4.0
Thought the application was helpful	4	5	4.5

5. *Open ended questions* Upon completion of the tasks, participants provided feedback for what they liked most and least about the application, and recommendations for improving the application. The three features that the participants liked most are; (i) the application updates itself for every 5 meters (e.g. tells straight on, turn, etc.), (ii) traces all the connections such as Wi-Fi, GPS and mobile network, and, (iii) the application will be useful when exploring new places.

The participants liked the least about the fix button, which to them are difficult to be found and pressed, and, the speech input synthesizer and output which were not that clear. As for improvement, they recommend that the application to include update about traffic light, busy roads and weather, to enable using headset to hear the speech output, and to include obstacle detection.

6 DISCUSSION AND LESSONS LEARNED

Based on the results, the users are satisfied with B-DiNAMA mobile application as it wasspecially designed for visually impaired users who face difficulties in reaching to new location they wanted to go just by using a smartphone powered by Android OS. It provides a memorandum function to help the visually impaired people to find particular destination and find the current location using speech input. Hence the functions provided by B-DiNAMA mobileapplication were developed and customized according to the needs of the blind users, despite the fact that it did not fully meet all requested features (obstacle detection). The result obtained was satisfactory and fulfilled as what have been expected. Based on participants' feedback, the pros of this application are it updated the directions every five meters, worked in any connections such as Wi-Fi, GPS and mobile network and it will be really useful in exploring new destinations. The cons of this application are; buttons and have to tap the screen to execute, and the speech output and input was not so clear.

The strength of B-DiNAMA as compared to other commercial applications as it allows the map to be pre-programmed to suit the user's location. With this feature, we liberate the users to navigate confidently to trivial locations nearby such as the canteen, toilet, lobby, which are all in the user's proximity, instead of listing out all places of interests (POI). Furthermore, B-DiNAMA is free of purchase.

However, there were a lot of errors faced during the testing phase of B-DiNAMA mobile application. Establishing an Internet connection and the GPS connection with the mobile devices was achieved with great difficulty as some of the areas have no Internet connection. Sometimes, the current location got updated late as that particular area has very low signal or no signal at all, resulted to slowly update of the overlay marker. As part of the solution, the application was set to optimize which provider has the best connectivity. Moreover, blind users were having rough time clicking the button to invoke an activity. Other than that, the participants had tough time when the instructions they given were interpreted wrongly by the speech recognizer synthesizer. It is because it was developed by the Americans and it was designed for them. The users, who are Malaysians need to correctly pronounce the words in American accent so the synthesizer can detect the instructions given correctly. They need to have proper training in order to speak the instructions in American accent.

We intend to take this study further by incorporating a larger number of visually impaired user in the user study.

7 CONCLUSION

In conclusion, participants found the B-DiNAMA mobile application to be a well-organized, comprehensive, clean and uncluttered, very useful, and easy to use. Implementing the recommendations and continuing to work with users will ensure a continued user-centered application to liberate the visually impaired users.

ACKNOWLEDGMENT

We would like to thank the *Jabatan Kebajikan Masyarakat* Johor Bahru for inspiring this study and participating in the pilot user study.

REFERENCES

[1] Google, "Google I/O",http://www.google.com/events/io/2011/index-live.html. 2011.

[2] Vlingo,http://www.vlingo.com. 2010.

[3] Case, A.B., Definition of and introduction to visual impairment in older persons, Nurse Homes, 1972, 21(3): p. 37 passim.

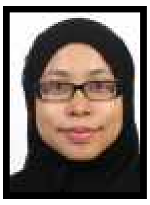
[4] M.A. Hersh and M.A. Johnson (Eds.) "Assistive technology for visually impaired and blind people", 2008, London: Springer.

[5] Loadstone GPS, http://www.4x4brasil.com.br/forum/navegacao-e-eletronicos/42393-vendo-gps-bluetooth-novo.html.2008.

[6] Nokia, "Wayfinder Nokia 6600 GPS mobile phone review", http://www.pocketgpsworld.com/wayfinder-nokia-gps.php#WayfinderMenu, 2004

[7] Visuaide's Busy Year: Honoured By CNIB, "Launching New Products And Opening A New Office", http://www.at-links.gc.ca/as/zx21015e.asp,2002.

[8] Android Becomes Best-selling Smartphone OS. http://www.pcworld.com/article/218219/android_becomes_best_selling_smartphone_os_says_canalys.html, 2011.



M. Ghazali received her B.Eng. in Software Engineering from University of Manchester Institute of Science and Technology (UMIST), England in 2001 and MSc in Distributed Interactive Systems from Lancaster University,England in 2002. She received her PhD in Computer Science from the same university, Lancaster University, England, in 2007. She is currently a Senior Lecturer at the Faculty of Computing, Universiti Teknologi Malaysia (UTM), Skudai. Her research interests include human-computer interaction, interaction design and user experience.

S. Pulanisamy obtained her bachelor degree in Software Engineering from Universiti Teknologi Malaysia (UTM) Skudai, Malaysia. Currently, she is employed at Altera Corporation in Penang as a Software Engineer.