SmartResponse: Emergency and Non-Emergency Response for Smartphone based Indoor Localization Applications

Manoj Penmetcha, Arabinda Samantaray, and Byung-Cheol Min

Computer and Information Technology, Purdue University,
West Lafayette, IN 47907, USA
{mpenmetc,samantar,minb}@purdue.edu

Abstract. In this paper, we present an Android based application that uses Wi-Fi fingerprinting technique to locate a person in an indoor environment with an accuracy of 1-2 meters in 70 percent and 2-3 meters in 30 percent of the test runs. This application can run in the background and whenever the individual requires assistance, their exact location along with a floor map image can be communicated to the appropriate authorities through an SMS, which is activated by pre-defined gestures such as swipe on a smartphone. We envision that the proposed application will assist people who are blind or visually impaired in navigating an indoor environment and in requesting assistance from other individual during their independent navigation.

Keywords: Emergency Assistance, Indoor Localization, Wi-Fi, Android Programming, Visually Impaired

1 Introduction

An important conclusion drawn during a series of interviews with first responders was that possessing accurate information about the exact location of a victim is of primary importance [1]. Obtaining such detailed information from victims suffering from visual impairment is very challenging as they use very specific landmarks (such as the number of turns, doors, etc) to navigate, which cannot be easily understood by first responders leading to inefficient problem redressal.

As the visually impaired community attempts to take a more active part in the society, they face multiple challenges ranging from reading a sign on the road to evacuating a building in case of a fire. To address these issues, many applications based on computer vision, smart-phones, sensors (talking OCR, GPS, radar canes, etc) have been developed [2,3,4,5], but most of them have very specific functionalities which renders them useless in many complex situations due to which a visually impaired person may require assistance from other individuals.

To ensure that assistance is provided as quickly as possible, it is extremely important that the location, description and the nature of the emergency is conveyed to the appropriate authorities. However, obtaining the location of a

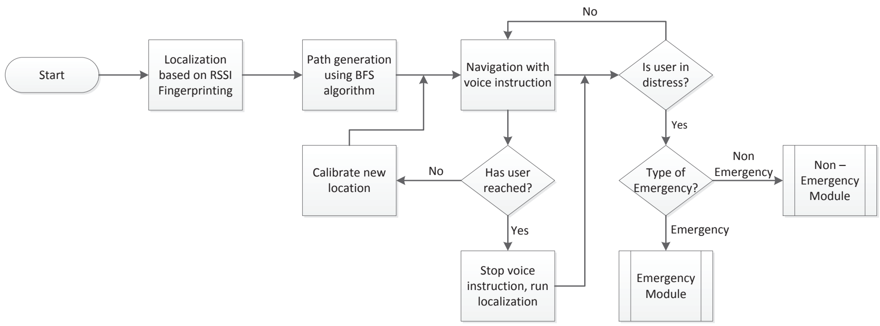

Fig. 1. A flowchart for the proposed smartphone application.

person in an indoor environment is a difficult problem. Various technologies such as sonar [6], beacons [7], vision [8], and Wi-Fi, have been explored to answer this problem. The easy availability of Wi-Fi makes it a lucrative proposition for many researchers who have used it for localization in indoor environments, through fingerprinting [9,10].

Our primary objectives in this research are first, to utilize the already existing Wi-Fi based localization techniques to build an indoor navigation application and second, to use this indoor navigation application as a basis to build an emergency and non-emergency based response system for providing assistance to people with visual impairment in the least amount of time possible. Through this app, we intend to overcome the absence of an emergency response system [11,12,13] specifically targeted for visually impaired individuals.

The application is built on the the hypothesis that using this application will help people suffering from visual impairments in navigating in an indoor environment and whenever required they can request assistance from the concerned authorities, and it would be delivered to them in the shortest amount of time possible.

2 Approach and Methods

The application has two primary functions. First, it is to accurately localize an individual in an indoor environment, thus assisting him/her in navigation. Secondly, the application is to request assistance in an emergency or non-emergency situation. The flowchart for the proposed application is shown in Figure 1.

2.1 Localization and Path Planning

We developed a reference coordinate system by dividing the entire floor plan into a grid. Subsequently, we fingerprinted each and every grid cell on the floor map and stored the Wi-Fi RSSI (Radio Signal Strength Indicator) strength range

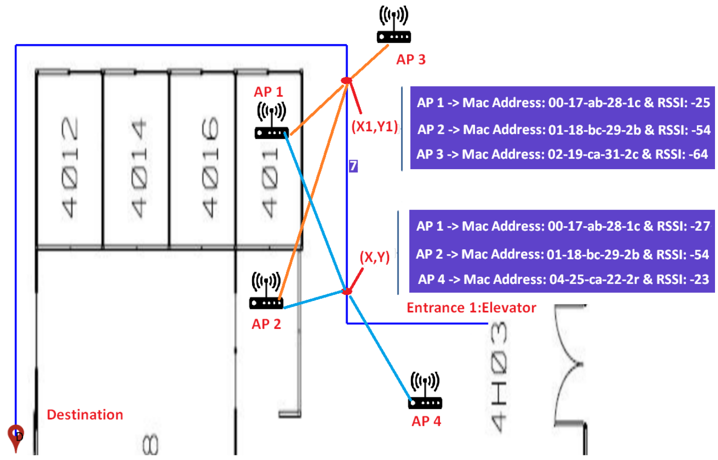

Fig. 2. An example of Nodes and its corresponding stored values.

from all the concerned access points into a database. These values would help us in uniquely identifying the node as shown in Figure 2. In Figure 2 we have a node (X,Y), which has three access points (AP1, AP2 and AP3) in its range. The RSSI values from these three access points can uniquely identify node (X,Y), and hence we store their corresponding Mac addresses and RSSI values.

Using the *WifiManager* API provided by the Android operating system, our application is able to find out the Mac addresses and RSSI values of each access point detected by the smartphone at any given point of time. These acquired Mac addresses and signal strengths are then compared with the existing database to find the location of the user. This function runs every 2 milliseconds to update the localization information of the user.

The floor map information was provided to the application in the form of a graphical data structure [14], where each node represents a grid cell in our reference coordinate system. Using this graphical data structure we were able to generate the shortest path between the user's starting location and chosen destination, by applying the BFS algorithm [15].

2.2 Graphical Interface and Voice Navigation

The current location of the user and the generated path is depicted on the screen of the Android device by using various classes provided by the Android API such as *Canvas*, *Drawable*, *Bitmap*, etc. Figure 3 shows the user interface of the developed application. Since the application is targeted for individuals suffering from visual impairments, direction's to traverse the path were provided in the form of voice instructions by using textitPico, Android's Text-To-Speech (TTS) module.

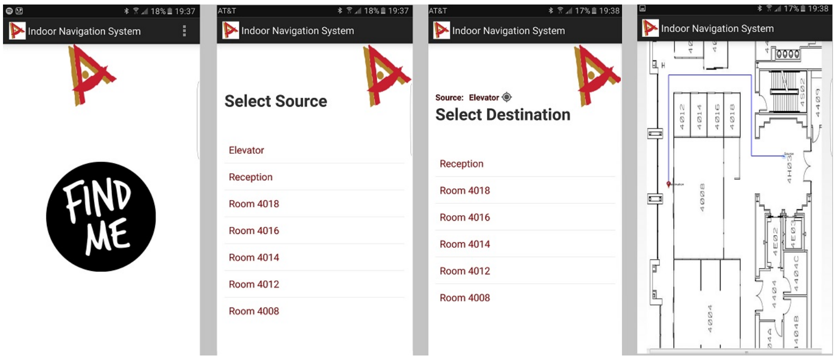

Fig. 3. Images showing screen-shots of graphical interfaces in the application.

2.3 Crisis Response

Our next step was to implement an Emergency and Non Emergency Response module in the application. This module can be invoked by using android gestures, such as a left to right swipe. When the user invokes this module, their location is sent as an SMS to the emergency or non-emergency response team along with a floor map,indicating the user's current location. Figure 4 shows the Emergency module implemented. The floor map sent along with the text message includes all the possible path's from each entrance point of the building to the users location and the shortest path among them will be represented by using a red line as shown in Figure 4.

3 Result and Analysis

The application was validated using an Android based Samsung galaxy S6 phone on the fourth floor of the Wang Hall at Purdue University. Android API 22 was used for developing the application and *Ubiquiti Nanostation* [16] routers were used as access points in the study.

As neither localization accuracy nor navigation was the priority of our project, to verify accuracy we set our margin of error to 22 percent and using normal distribution we derived the sample size to be 60. The application was test run 60 times and the results acquired varied from 1.5 meters to 3.5 meters with Wi-Fi signal fluctuations playing a major role in determining location accuracy. Figure 5 shows the bar chart indicating percentage accuracy at different locations. As shown in the figure, an accuracy of 1-2 meters in approximately 70 percent in the most locations and 2-3 meters in approximately 30 percent of the test runs could be achieved. Since the localization accuracy of the application was in the range of 1.5 meters to 3.5 meters, as it was completely dependent on Wi-Fi signal strengths, it might not be an ideal solution for indoor navigation considering the visually impaired people would require higher accuracy of localization for their independent navigation. Nonetheless it can serve the purpose of emergency

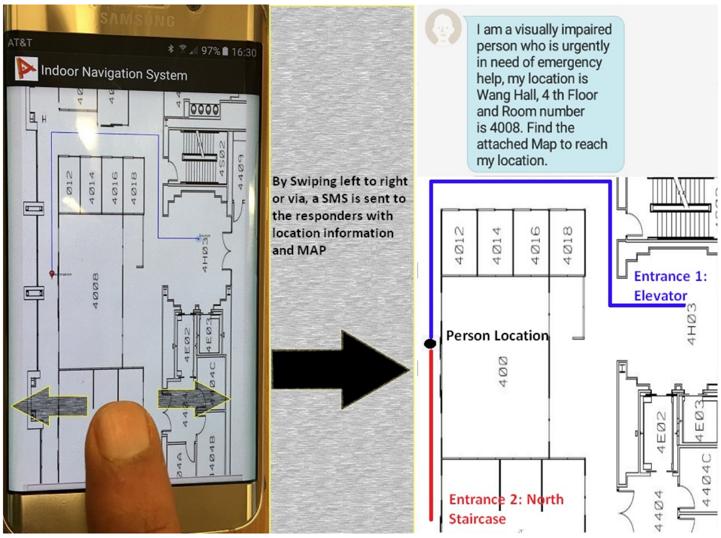

Fig. 4. MMS with text and an image of the current map (right) are sent to responders when performed a gesture (left).

or non-emergency response for people with visual impairment well as the first responders would have to search for the person only within a 3 meters radius rather than through the entire building.

4 Conclusion and Future Works

4.1 Conclusion

This paper presents the prototype of a navigation system that helps the visually impaired to navigate within indoor environments. The results of the preliminary tests indicate that the solution is feasible and useful and can guide the user in indoor environments. However, it is important to conduct more rigorous experiments and involve visually impaired people to understand the true effectiveness of our system and improve upon it further.

4.2 Future Works

Our main motivation while developing this application was to create a platform on which we can add more features and hence develop a highly personalized piece of software that could help the visually impaired community in leading an independent and better quality of life.

To achieve this aim, we are currently working on developing a system that allows the smartphone camera to detect the presence of any stationary or moving

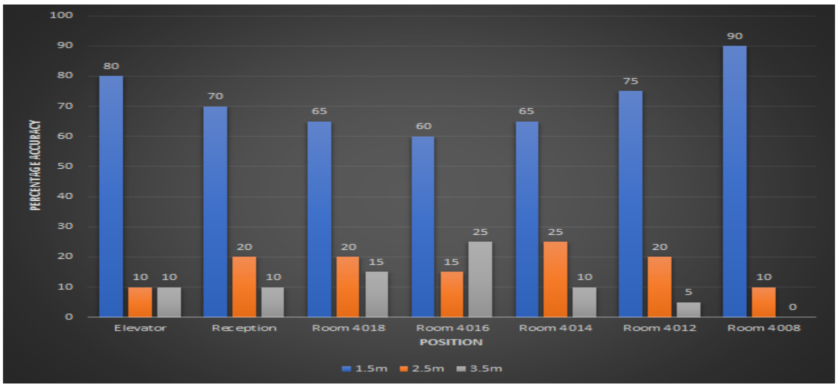

Fig. 5. A Bar chart indicating percentage accuracy at different locations.

obstacle and provide voice feedback to the user so that the user can take appropriate measures. Also, we intend to deploy RFID tag readers that would allow any users to scan the RFID tag, and then be able to obtain all the necessary details such as the various access points, their signal strengths at various points on a floor plan, and all the other requisite data that are necessary for using the application to provide localization and navigation features when a user enters a new building.

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