Indoor Navigation for Visually Impaired / Blind People Using Smart Cane and Mobile Phone: Experimental Work

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Abstract
This paper suggests a navigation structure for visually impaired/blind people. The proposed structure is consisted of builder simulator, smart phone with built-in compass and cane. The aim is to guide visually impaired/blind people from a required location to a desired location. Multi tests are run where modeled in C sharp and java languages and MATLAB program using A* algorithm. Experimental results show good performance for the proposed scheme that the visually impaired/blind people reach the desired location successfully without error. In conclusion, A* path finding algorithm using C sharp language for builder simulator, and java language for smart phone, were valid and reliable methods to guide the visually impaired / blind people from a required location to a desired location in indoor environment with or without obstacles.
Keywords: Smart phone, built in compass, cane, planning the path, avoidance obstacles, visually impaired/blind people, A* algorithm, path finding, and indoor navigation

1. Introduction

One of many supports that is urgent is the guarantee of mobility for blind people. There has been many efforts but even now, it is not easy for blind people to independently move [1].

Wireless Based Indoor localization unlike light, wireless wave can get through doors and walls and provide ubiquitous coverage of a building. Wireless based indoor localization uses features of received signal to infer the distance to known points and get the location of current point. The architecture of wireless based indoor localization system usually requires two parts, the beacon stations that emit the wireless signal and the user devices that receives the signal or versa vice. GPS can also be included as a wireless based localization technology. It uses wireless signals to communicate between satellites and the GPS devices. The propagation of wireless wave can be influenced by reflection, scattering, and diffraction. The signal strength can be affected by multi path fading or shadow fading. In indoor environment, the walls, furniture or walking people will change the propagation of the wireless wave and introduce variance to the wireless signal received by the user. For evaluating a localization system, several criteria for localization are illustrated in Figure 1 [2-5].
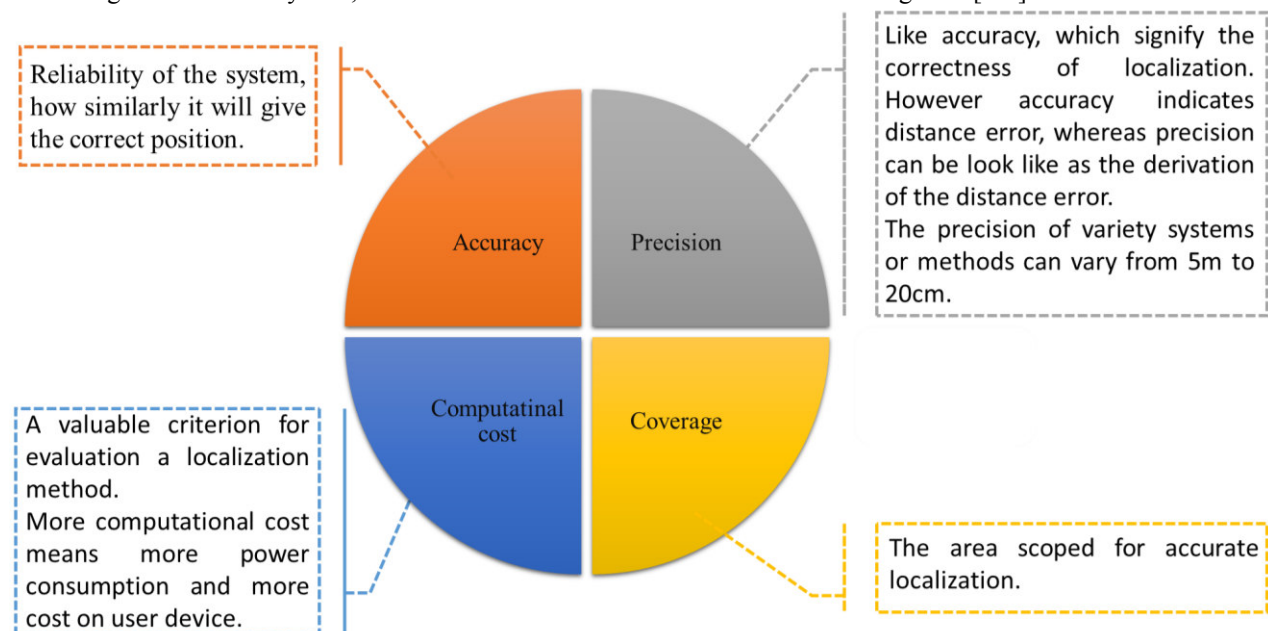

Figure 1: Localization system criteria [2-5].

Zhang et al. (2014) [6] described an indoor positioning algorithm for mobile objects based on track smoothing. Considering the effects of indoor environment and the individual anchor nodes, the algorithm was realized in two filtering phases to modify the UWB range measurements and the trilateration localization results by the Unscented Kalman Filter.

Chuang et al., (2014) [7] focused on touchless positioning sensing devices using infrared (IR) light-

emitting diode (LED) and proximity sensor. The signals from a set of proximity sensors are used to determine the position of the hand through the trilateration method. The distances between hand and sensors can be obtained from proximity sensors. The positioning results of hand are verified over mobile devices. This design can waive the necessary of touching the touch panel or screen of mobile device.

Chaudhry and Chandra (2015) [8] presented design of a mobile face recognition system for visually impaired persons. With the availability of mobile devices, an additional method of identification through intelligent software based on computer vision techniques assisted visually impaired people. The mobile system was assisted by a server-based support system and was tested on a custom video database.

Huang et al., (2015) [9] proposed Kalman-filter drift removal (DR) and Heron bilateration location estimation (LE) to significantly reduce the received signal strength index (RSSI) drift, localization error, computational complexity, and deployment cost of conventional radio frequency identification (RFID) indoor positioning systems without any sacrifice of localization granularity and accuracy. By means of only one portable RFID reader as the targeted device and only one pair of active RFID tags as the border-deployed landmarks, this paper developed a real-time portable RFID indoor positioning device and cost effective scalable RFID indoor positioning infrastructure, based on Kalman-filter DR, Heron bilateration LE, and four novel preprocessing/post processing techniques.

In this paper, experimental work applied in an indoor localization of visually impaired / blind people. Multi tests are applied with and without obstacles in indoor navigation based on smartphone and compass sensor, our overall system consists of map builder programmed using C sharp, built-in compass which work to get the current direction of the visually impaired/blind people and mobile application programmed using java language to guide the visually impaired and blind people.

2. Vector Technique and Compass Sensor with Path Finding Algorithms

Path finding algorithms in the basic definition is moving an object from its initial position to the final location [10]. These algorithms could also be used to find the shortest path to drive between two points on a map, the most used algorithm in today's games is the A* Algorithm. "What makes the A* algorithm so appealing is that it is guaranteed to find the best path between any starting point and any ending point, assuming, of course, that a path exists" [11].

A* is one of the many search algorithms that takes an input, evaluates a number of possible paths and returns a solution [12].

In vector technique, mathematical equations that deal with how to find angle from two points (angle of vector) these points already obtained from A* algorithm so the equation we obtain as bellow:

$$p_0(x, y) \tag{1}$$

$$p_1(x, y) \tag{2}$$

$$(p_0 p_1)_x = p_{1x} - p_{0x} \tag{3}$$

$$(p_0 p_1)_y = p_{1y} - p_{0y} \tag{4}$$

$$\theta = tan^{-1}\left(\frac{y}{x}\right) \tag{5}$$

Then to correct the direction of the person we using compass that it is built-in mobile and compare the obtained the values with vector angle.

Cane and beacon explained in next section, our overall system shown in Figure 2.
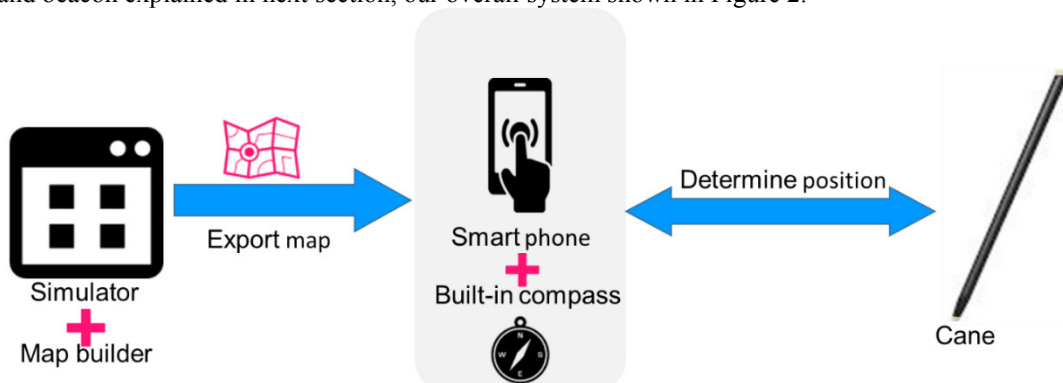

Figure 2: Overall system

Our built program contains the following illustration:

1. Overview and benefit

We are design the simulation software (building) to show how it work and can be used to export the map directly to the mobile to be used with the same algorithm but in android java .The application is contain many parts and we explain each part separately, as is shown in Figure 3.
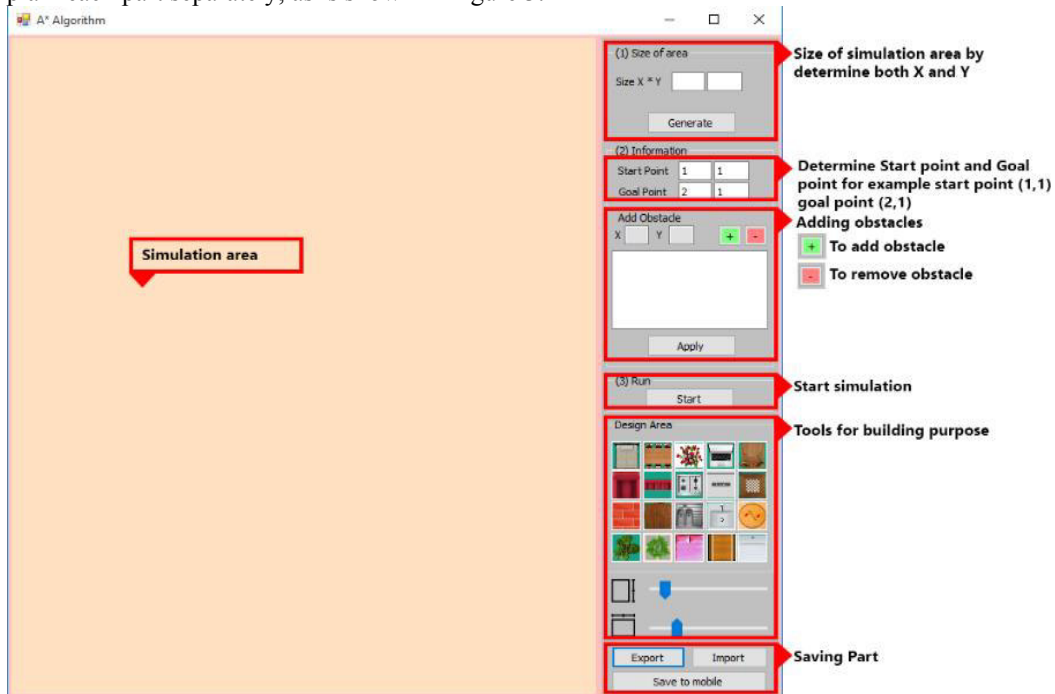

Figure 3: Parts explanation

2.   Application specification

The specifications of each part is illustrated in Table 1 below.

Table 1: Parts specifications

	Coding language	C# 2013 .Net framework 4.5
	Ram	> 32 MB
	Hard disk	At least 64 MB
	Operating system	Windows xp, 7 , 8 , 8.1, 10

3. Building map

a.   Setting area size: Can easily determine by set the value of it and press generate button to start generating the simulation area, through this time the progress bar will be shown until finishing the process of generation. Figure 4 is shown the details.
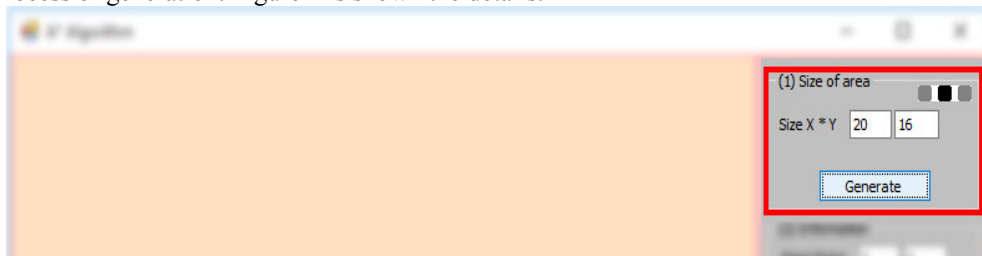

Figure 4: The details of setting area size

After generating complete then will be show as Figure 5 below.
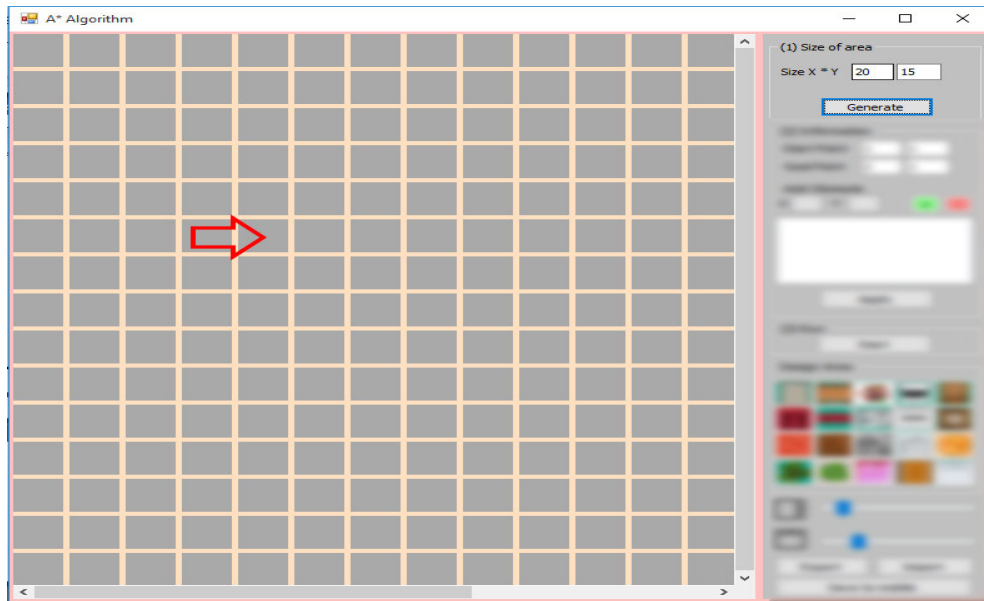
Figure 5: Result after generating complete

b. Setting start and goal point: There are two options to setting the start and goal point, either directly entering the point of it or using Right click mouse button and select the "set as start or goal", as is shown in Figure 6.
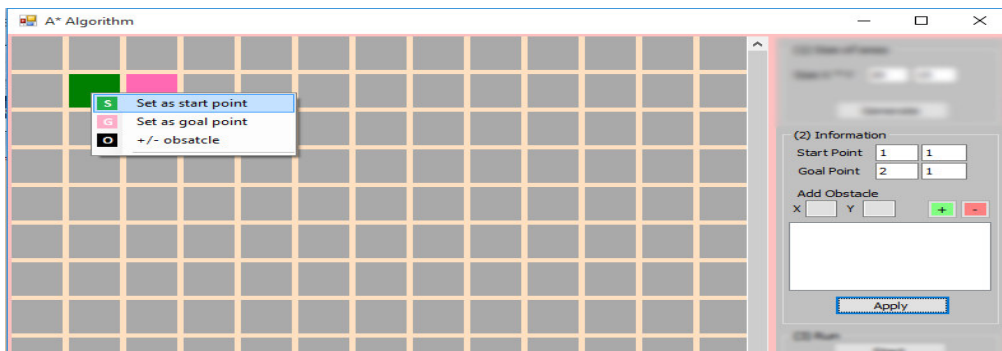

Figure 6: Setting start and goal point

c. Setting the obstacle location: Same as previous method we also can set obstacles.

4. Import and export map.
This function used to save the created map to be used later by load it to this builder or can be used for the present mobile application.

3. **Mobile Application for Visually Impaired/Blind People**
When run the application for first use, the first activity will have shown is to choose the language. There are two languages are currently available in our application, Arabic and English language. Figure 7 shows the activity for first use to select language.
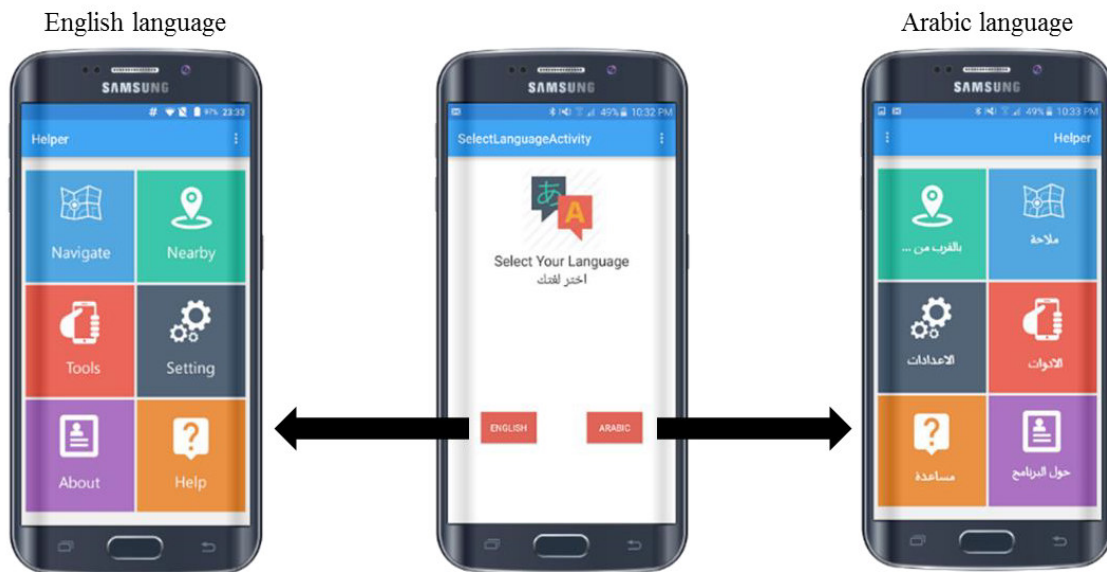
English language

Arabic language

Figure 7: The activity for first use to select language.

The blind/visually impaired people can use it easily by pass finger over the screen (by touching it the six grid). The blind/visually impaired people will hear the command with him/her selected language. If the blind/visually impaired people want to select anything can use the long touch after hear the command until vibrate the mobile phone to indicate the mobile perform the action, as shown in Table 2.

Table 2: Event and Action

Event	Action
single touch	Hear the sound of the touched things.
long press	Perform the action of the heard sound command.

Additionally, for first use they should go to the "Setting" to insert the map and calibration the compass these things we will explain later. If the blind/visually impaired people touch the upper left of the screen he/she hear sound of the "/navigate/" word.

If the blind/visually impaired people want to make navigation to specific location, by long press on this location of the screen and wait the vibration of the phone to make feedback to the user that the application perform the action that wanted. After make long press on the navigation then new activity shown as in Figure 8.
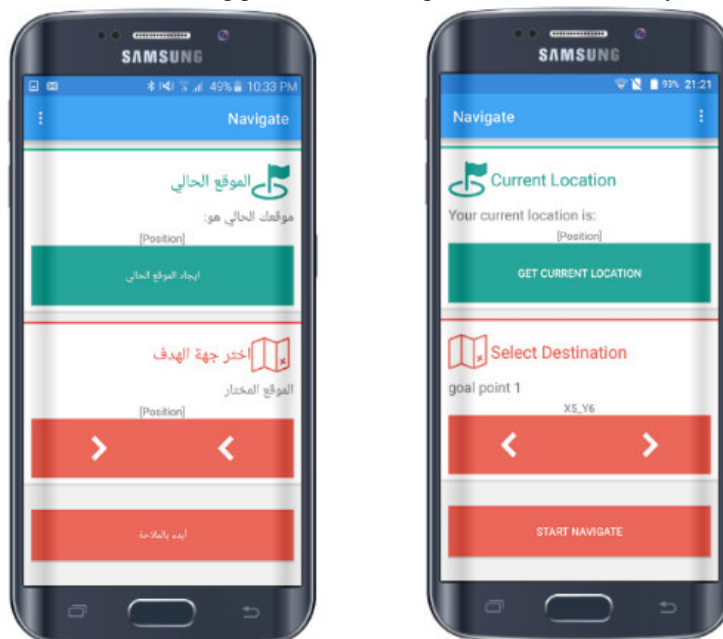
Figure 8: New activity

This screen is containing the screen contain three parts, these parts are also touchable to hear the sound of each it. The first part, is for determining the current location by connect wirelessly with the cane and get the information form it.

If the process of determining location success, then the blind/visually impaired people will here successful message else if "Try again please".

The second part is selecting the destination location by touching the two arrows to choose where he/she want to go.

The final part in this activity is start navigate button, this button checks if the blind/visually impaired people already select the current location or not if not they hear sound message "please determining current location first", with the same way, also check the destination location if not selected they hear sound message "please select the destination location first".

If all thing is correct the application shown guiding activity, A* path finding algorithm performs with these parameters (current location, destination location) and using vector technique and built-in compass sensor dependently with the stride length.

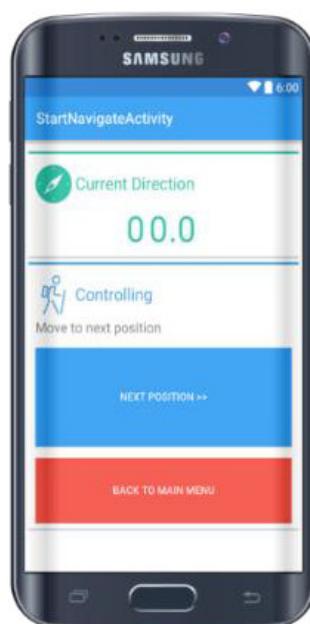Taking into account the average length of step, as in [13]. Figure 9 below shows the guiding activity.

Figure 9: Guiding activity

Setting button show the new activity, as shown in Figure 10.

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ISSN 2224-5782 (print) ISSN 2225-0506 (online)
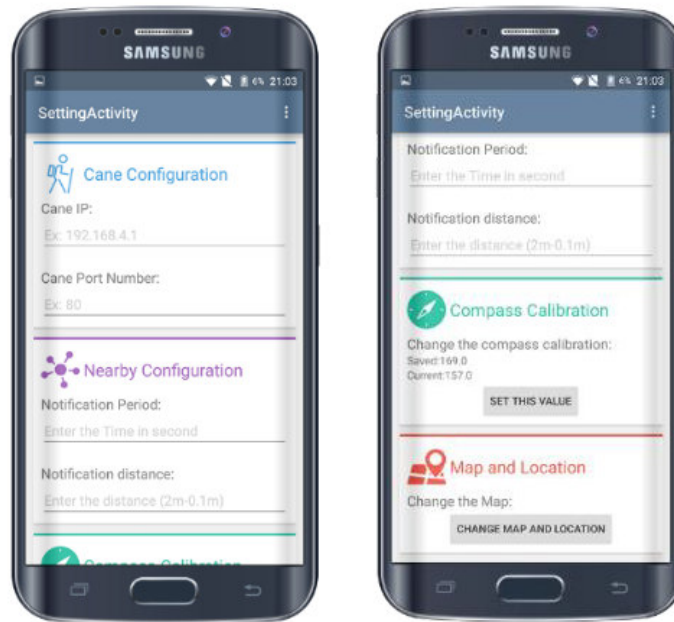Vol.6, No.5, 2016

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Figure 10: Setting button

In the first part is cane configuration the part contain two things: cane IP and the port number of the cane. In the second part contain the Nearby Configuration which contain the notification period and the distance. In the last part is the Map and location to load map can load from SD cart of the mobile or from local server, about and help activity as shown in Figure 11and Figure 12 respectively.
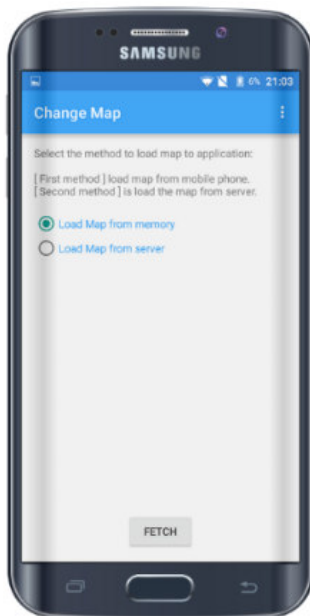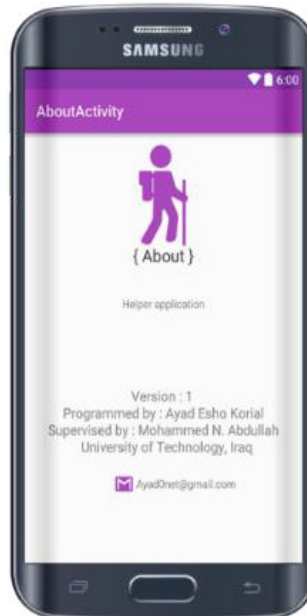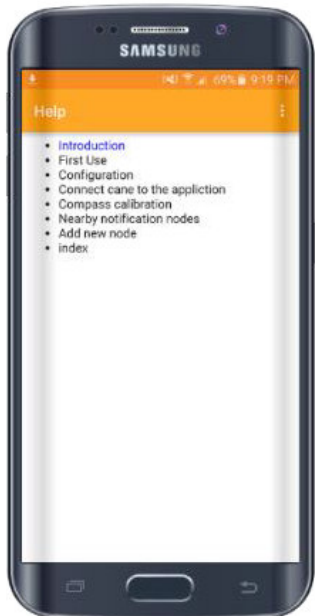

Figure 11: Map and location

Figure 12: About and Help activity

4. Cane System Design

Our cane system design consist of arduino, ESP8266 Wi-Fi and RFID reader. Figure 13 shows cane system design.
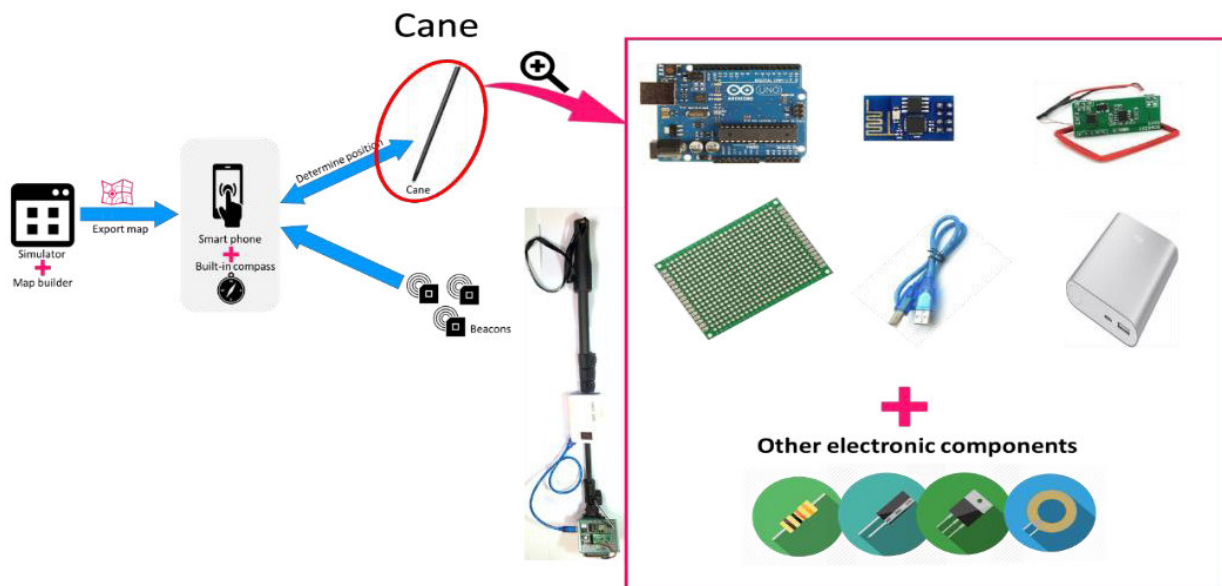
Figure 13: Cane System Design.

4.1 Overall system scheme

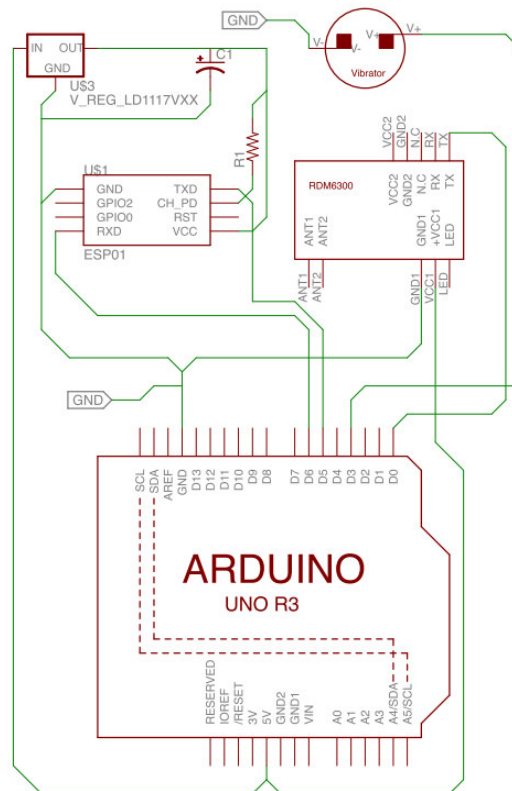Our overall system scheme is shown in Figure 14.

Figure 14: Overall cane system scheme

4.2 Cane code life cycle

Cane code life cycle can be summarized in the following steps:
1. Operate the cane module.
2. Microcontroller in the cane circuit automatically initialize some value.
3. Microcontroller perform the subroutine by calling the Subroutine_setup.
   A. Perform setup subroutine.
   B. Enable the hardware serial port pins (Rx and Tx) at D_0 and D_1 respectively to use it for RFID reader.

    C. Initialize the hardware serial port by setting its baud rate to 9600.
    D. Enable the software serial port pins to use it for ESP8266 module.
    E. Initialize the software serial port by setting its baud rate to 9600.
    F. Reset the ESP8266 module.
    G. Configure the ESP8266 as access point by setting its mode to 1.
    H. Configure the ESP8266 for multiple connection by setting CIPMUX to 1.
    I. Turn on the ESP8266 as server on port 80 by setting its CIPSERVER=1,80.
    J. Initialize the PIN D3 of the ATMEGA microcontroller for vibrator.
    K. Return form the subroutine.

4. If RFID reader did not detect any tag then wait to detect tag else go to step 5.
5. Enable the vibrator to vibrate the cane, this vibration works as notification for visually impaired/blind people that the cane detected a tag.
6. Get the data of the detected RFID tag.
7. Put the detected data on ESP8266 server at specific port number and IP address.
8. Send data value back to mobile.

4.3 System hardware results and discussion
A) Planning the path
In run 1 where the visually impaired/blind people is moved from start position (1,7) to goal position (4,1). The evaluation of path points are done in distance unit using Matlab. In run 2 where the visually impaired/blind people is moved from start position (1,6) to goal position (5,6). The evaluation of path points are done in distance unit using Matlab as shown in Figure 15 for run1and Figure 16 for run 2 respectively.
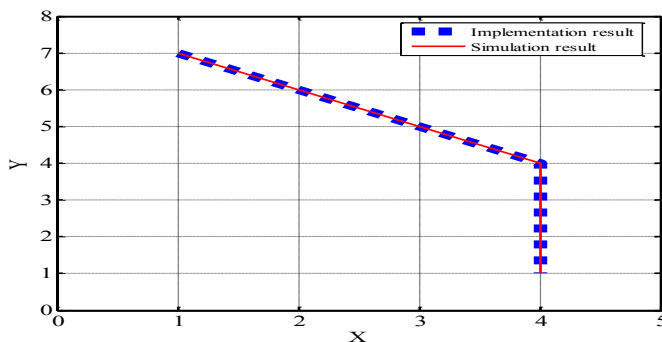

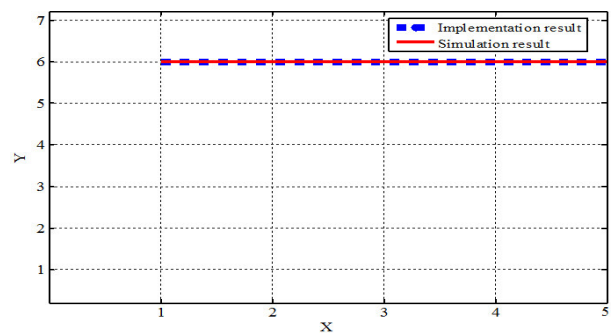**Figure 15:** The evaluation of path points of run 1

Figure 16: The evaluation of path points of run 2

B) Avoiding obstacles
In run 1 where the visually impaired/blind people is moved from start position (12,3) to goal position (7,5). The evaluation of path points are done in distance unit using Matlab as shown in Figure 17 for run 1, In run 2 where the visually impaired/blind people is moved from start position (6,4) to goal position (3,8). The evaluation of path points are done in distance unit using Matlab as shown in Figure 18 for run 2.
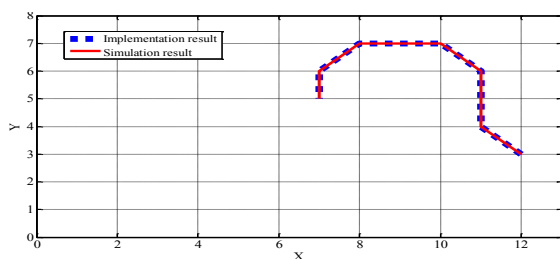

Figure 17: The evaluation of path points for avoiding obstacles of run 1

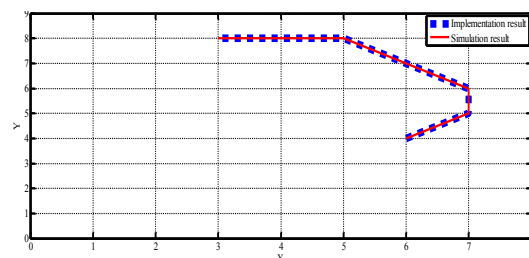**Figure 18:** The evaluation of path points for avoiding obstacles of run 2

5. Conclusion
A star path finding algorithm in experimental work using C sharp and java languages guided the visually impaired / blind people using mobile with built in compass and cane from a required location to a desired location in an indoor environment with and without obstacles. This method was valid and reliable.

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