Enhanced Navigation Cane for Visually Impaired

R. Akhil, M. S. Gokul, Sarang Sanal, V. K. Sruthi Menon and Lekshmi S. Nair

Abstract Vision is an important aspect of brain functionality as it allows us to view our surroundings, and maintain the incisiveness of our mind. For a blind person, to walk without resistance, is the most difficult task. Visually impaired are compelled to depend on others for conducting daily activities, especially walk outdoor. As a humanitarian service, our paper aims to help the blind people to walk independently and enjoy the freedom of walking. The model we present here act as a virtual eye to the visually disabled persons, which helps them to navigate to their destinations without the help of others. This model uses a mobile app, concurrent with the lately developed system using the fundamental principles of Arduino Uno board is based on ATmega328 microcontroller. This module is appended to a walking stick so that it is manageable by a blind person. The sensor in the apparatus returns the span warns with a sound alert if any target can be deleterious to the blind person. The system brings a new domain, Internet of Things (IoT), to the fore of the blind people, to make their existence uncomplicated.

Keywords GPS · Ultrasonic sensor · Arduino UNO board · Google API

R. Akhil · M. S. Gokul · S. Sanal · V. K. Sruthi Menon (✉) · L. S. Nair
Department of Computer Science, Amrita School of Engineering, Amrita Vishwa Vidyapeetham, Amrita University, Amritapuri, India
e-mail: menonsruthi96@gmail.com

R. Akhil
e-mail: akhildesigns07@gmail.com

M. S. Gokul
e-mail: gokulms200@gmail.com

S. Sanal
e-mail: sarangsanals@gmail.com

L. S. Nair
e-mail: lekshmisn@am.amrita.edu

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1 Introduction

Research says that about 40% of the blind population of the world are from India, and 75% [1] of those cases are mostly unavoidable cases of blindness. Freedom of movement is a great hindrance as far as a blind is concerned. The blind normally carry a white cane or have their own guide dog. Researches are being conducted for helping the blind. There are many existing products which can help the blind detect obstacles in front of them. Nevertheless, these blind-aid products would be of minimal use if the visually impaired wish to walk out doors, especially at unknown places. To precisely address this inadequacy, we have developed an Android Application with a walking stick which help the blind navigate themselves to their destinations. The add-on module affixed to the cane, captures all the hindrances along their path, whether a step or a pit, or any obstacle. The guide-module is integrated with voice capability, to chaperone the blind by voice alerts. This is achieved by incorporating an application software especially designed for the blind people.

2 Related Work

Some similar models have been developed as an explication to the freedom of navigation for the blind. In the Sound and Touch based Smart Cane, [2] the authors have proposed the technology of Arduino and a mobile app that detects obstacles in front of them and make them aware of the obstacle using Bluetooth headset. Vibratory motor attached to the hands vibrates with the speed of the object appearing in front of them. In this model also it gives the blind if some obstacle is in front or not. But it is not necessary for a blind to walk. It also needs the navigation which is one of the most important.

In a navigation system for visually impaired, intelligent white cane [3], the authors have used the basic principle of image processing to find obstacles near them and compute the receding distance to the obstacle ahead.

The authors of Location Based Services and Integration of Google Maps in Android, have [4] suggested a location based service (LBS) system of the Android app to obtain navigation assistance to the desired destination. It is mainly using Java Script Object Notation (JSON) string which is extracted and processed to get the navigation as output.

The team of the Multiple Distance Sensors (MDS) Based Smart Stick for Visually Impaired People [5] also used the same idea of ultrasonic sensors, to detect objects in front of a person to facilitate their travel movements. The values acquired by the sensor are compared with a threshold value; if the sensor-detected value is less than or more than the threshold, an alert message is passed to the head phones via a Blue tooth connection.

In the paper, Voice Assisted Navigation (VAN) System for the Blind, [6], the authors have developed a system for the blind to walk, using ultrasound waves which is used to detect any obstacle. When the echo signal is sent, the count variable starts counting, and if received back the counting stops and it switch to the value of the count. Accordingly, the audio output is being played. VAN also helps in detecting the gradient in the ground by using the previously defined value and newly calculated value. VAN detects whether it is a pit or slope. But even if it says it gives navigation it just based on the obstacle that occurs in front it does not gives the direction where the blind has to go.

NAVI: Navigation Aid for the Visually Impaired [7] is based on image processing technique. Video of the person is being captured as the person walks using mobile camera and checked in remote server to identify object using the image processing techniques. Calculations are done with Depth estimation, Grid approach, Segmentation to find about the object. Various sets of short videos are stored in remote server. Captured video are compared with stored situations and the object is identified. Image processing techniques are a bit slow for a dynamic objects it's not effective and has a larger delay.

Moving Direction for Visually Impaired People [8], detection of real time objects along with the moving direction is presented. Up-stair, down-stair, moving escalators are detected using video camera based system. In this system also it doesn't give a proper navigation for the blind and also uses the image processing which makes it slow.

There exists an electronic escort system [9] which is a skipper for the blind people using the stockpiled values in the local database, and finds the track of the blind, using a special type of sensor, attached to the walls of the room, which is unfeasible to elongate to the outdoor.

3 Proposed System

The proposed model aims in answering the drawbacks identified in the related work. The proposed model is designed in such a way so as to provide an outdoor navigation along with detection of any obstacle in the front. The cane in the proposed model is attached with an ultrasonic sensor, a Bluetooth module, an Arduino Uno Board and an internet device on which the specially designed navigation application is integrated. First, the destination is taken as the voice input through the navigation application. A HTTP connection is established with the application. This will start the navigation for the blind. The ultrasonic sensor, attached to the stick, detects any obstacle in front of them. If an obstacle is identified, the distance at which the obstacle located is calculated by the Arduino board. This distance is sent to the mobile application via the Bluetooth module connected to the Arduino as given in the Fig. 1. If an obstacle is in the range of 10–100 cm then a warning sound message is given through the app. The navigational directions are delivered as a voice output, throughout the blind person's journey.

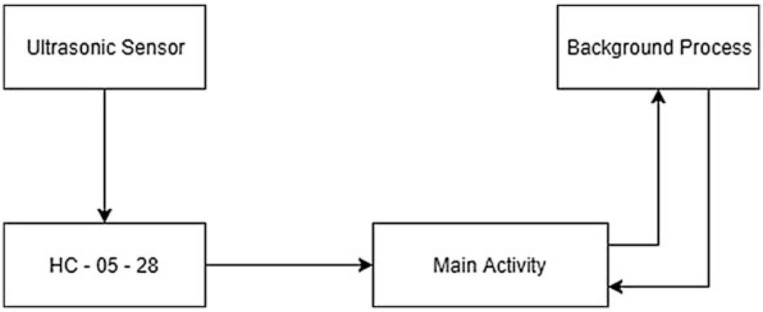

Fig. 1 Basic architecture

4 Component Details

4.1 Cane

A white steel cane of a 3/4th length of a normal person height is used to prototype walking stick. Top portion of cane is designed in a way blind will never feel much weight of cane and box when lifting while walking. The cane is affixed with 10 cm $\times$ 10 cm square box for placing circuit boards and Bluetooth module.

4.2 Ultrasonic Sensor

4.2.1 Obstacle Detection

Obstacle detection, ultrasonic sensor is used to detect obstacles in front of the sensor. Ultrasonic sensor sends ultrasonic rays at 180° in 0.034 m/s. When these rays' touches an obstacle, the ultrasonic waves are reflected back, which are received by a receiver in the ultrasonic sensor module as shown in Fig. 1. Time for transmission and receiving of rays are noted. Distance is calculated by the following formula:

$$\text{Speed} = \text{distance} * \text{time} \tag{1}$$

From the speed of the ultrasonic waves returned the distance at which the obstacle is situated is calculated and compare this value with the threshold value which is set at the Application so as to expect the obstacle at nearby. The system is designed such that if the object is in front under the range of 10–100 cms. Alert voice output is set with Obstacle Text To Speech message as in Fig. 5.

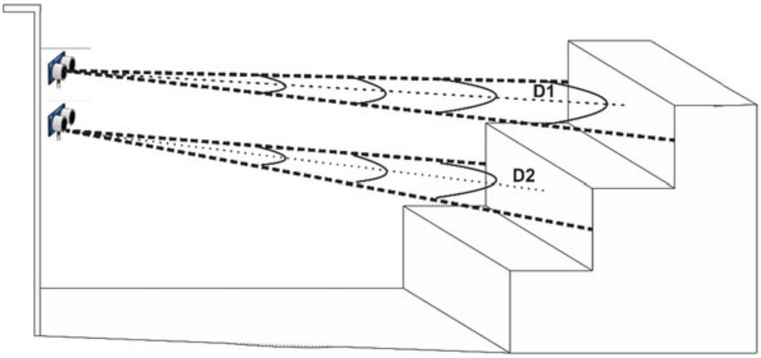

Fig. 2 Obstacle and step detection

4.2.2 Step Detection

As in Fig. 2 two ultrasonic sensors are set at 15 and 30 cm above ground level on the cane. 15 cm separation is maintained between two sensors, in order to avoid interference from overlapped ultrasonic rays. Ultrasonic rays are transmitted from a transmitter in the event the rays strike any object, they are reflected back, which are captured by a receiver in the ultrasonic module. From the times of transmission and reception of rays the distance of the object is calculated. Comparing these distances from the two sensors, a step can be detected. Alert voice outputs are initiated through the Step Text To Speech module, shown in Fig. 5.

4.3 Arduino

Arduino Uno, is one of the most popular micro controllers, used for the applications of IoT. UNO is based on ATmega328 microcontroller. UNO boards the latest board of the Arduino with all the features. In this research, we used Arduino board to integrate ultrasonic sensor and Bluetooth module to push value to application. Arduino provides power supply for all module attached to it.

4.4 Bluetooth (HC–05–28)

HC-05 is an easy to use Bluetooth module with a serial port. It is designed for transport wireless serial connection. This module is mainly used for transmitting data between micro controller and Android devices. Configuring micro controller will enable Bluetooth and can pair with Android device so that data can be sent to

Fig. 3 Proposed system

and fro. Values from sensors are send to Android for comparison through Bluetooth module.

The Bluetooth module and the Arduino board are assembled into a box structure as in Fig. 3. A small heat sink which works on 5 V is also connected along with. This prevents from overheating of Arduino UNO board.

4.5 Android Application

The application is built on Android platform using Android studio. Application requires BLUETOOTH, INTERNET, ACCESS FINE LOCATION permissions given for proper working. It initiates with the Google mike on the enabling of the application as given in Fig. 6. This application is developed for SDK 24 and minimum Android version required is 5.0. The current location of the person is fetched using GPS (Global Positioning System) implementing location listener as in the Fig. 7.

4.5.1 Background Processes

In the Background REST (Representational state transfer) takes places. It is a web services which enables to communicate between the two different languages. Here it helps to communicate between the JSON string and the Application.

HTTP Connection

To get direction to the person's desired location, we have submitted a request with Google API to get direction. HTTP Connection is a background task in Fig. 4. It works on background Async task to get direction from Google using Google API. It uses INTERNET permission, with current location, destination and Google API HTTP request is established to get JSON (Fig. 4).

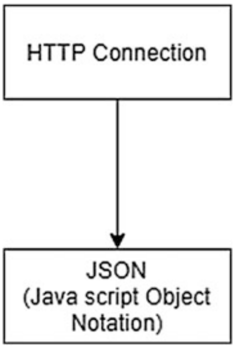

Fig. 4 Background process

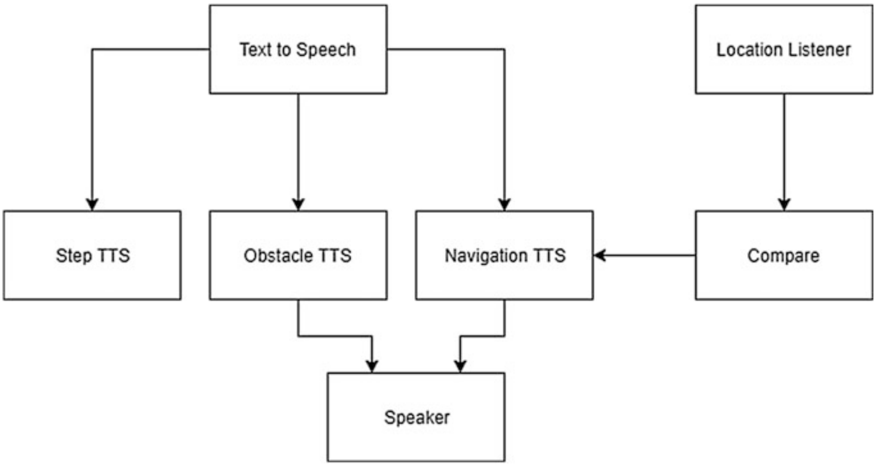

Fig. 5 Main activity

JSON (Java Script Object Notation)

JSON is a data exchange format for easy and simple transfer of data. This application uses JSON string for exchange of data. JSON string is parsed into its components, noted as follows:

1. **ROUTES**:

   It consist of latitude and longitude of source, destination and Legs.

2. **LEGS**:

   Legs consist of total Distance, total Duration, start address, start location, end address, end location.

3. **STEPS**:

   Steps consist of:

A. distance to next deviation.

B. duration time calculated normally to reach next deviation.

C. end-location latitude and longitude of next deviation point.

D. html instruction of next deviation.

E. start location latitude and longitude of current deviation.

4.5.2 Main Activity

Location Listener

Location Listener is a package used to refresh GPS location in Android application. While walking, location of the blind person will get regular updates from this application. Latitude and longitude parameters of the location of blind is updated in application, using Location Listener.

Google Application Programming Interface (API)

When a blind wishes to move to some destination, the directions are received from Google, via the Google API application. Google API is interoperable with different services like Google maps, which facilitates additional functionalities made available from the system we have proposed. Google API is a key implemented in this application to get direction from Google.

Algorithm for Navigation

Data: current latitude, longitude, Json latitude, json longitude

Result: HTML instruction

```
if Currentlatitudejsonlatitude
0:00002kcurrentlongitudejsonlongitude < 0:00002
then
return true;
else
if roundedcurrentlatitude == roundedjsonlatitude
then
return true
else
if (roundedcurrentlongitude == roundedjsonlongitude then
return true
OUTPUT HTML INSTRUCTION
else
return false
end
return false
end
return false
end
```

Algorithm 1: procedure of navigation

Algorithm 1 was designed to enhance the Navigation feature of the proposed system. The latitude and the longitude of the current location is determined using GPS. HTTP (Hyper Text Transfer Protocol) Connection is established. Returns the JSON String. From JSON string, the start latitude and start longitude information is extracted. If the difference between start longitude and current longitude is less than 0.00002 it returns true. Round off the current latitude and current longitude into three digit decimal. Round off the JSON latitude and JSON longitude into three digit decimal. Check if current latitude and longitude and JSON latitude and longitude are equal. If returned true the HTML instruction is given as output. Voice output of HTML instruction is set through navigation TTS as in Fig. 5.

5 Experimental Results

The model was experimented on a blind person, the distance of obstacle calculated by the ultrasonic sensor was verified. A time delay was observed, which include the delay from the sensor, Bluetooth module and the Android application. The sensor range was predefined as 10–100 cm, which gives a negligible delay of 0.03 s. The Android app experience a delay, which depends on the speed of internet connection, time required to compute the path (in seconds) was also verified. This is shown in Table 1. In the Fig. 6 it shows the automatic enabling of the android application which enables the Google mike which records the destination. And in parallel the location of the person is also taken as given in the Fig. 7. And it gives the output of the html instructions as in the Fig. 8.

Table 1 HTML instruction

Internet connection	Time required to find the path (s)
4G	1.65
3G	3.55
2G	8.10

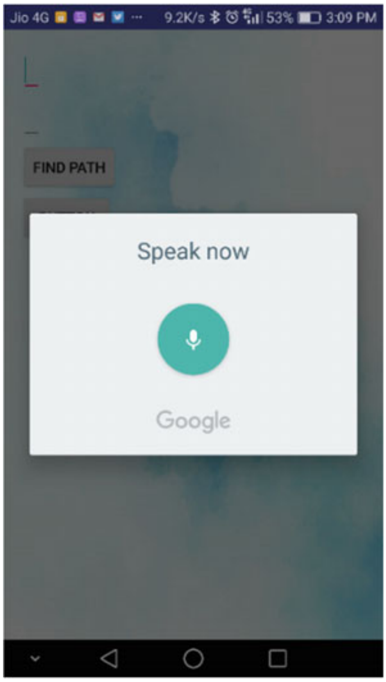

Fig. 6 Voice detection

Fig. 7 Location detection

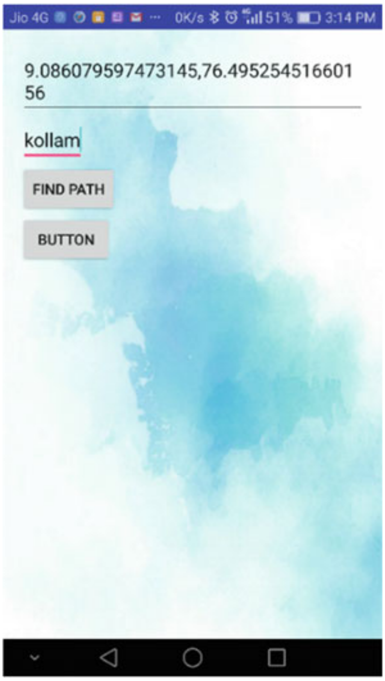

Fig. 8 Path activity

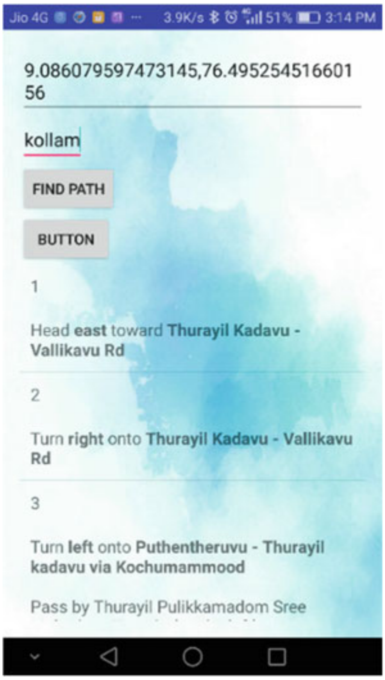

Table 2 Step and obstacle detection

Serial no	Sensor S1 (cm)	Sensor S2 (cm)	Difference (cm)	Inference
1	156	171	15	Stair upwards
2	172	173	10	Obstacle present
3	78	96	18	Stair upwards
4	4220	4224	4	No obstacle

Various experiments were conducted to detect the stair upwards. The inferences is recorded in Table 2.

Obstacle detection and upward step detection where experimented and recorded as follows in Table 2.

6 Conclusion and Future Work

The model was designed to obtain a hassle-free movement for the blind at outdoor unfamiliar places. This model was also designed to be cheaper compared to the available products in the market. Ongoing experiment includes pit detection which are currently out of the scope of this paper.

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