Navigation Guidance and Interactive Mobile Application Features for the Visually Impaired

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Abstract--*Visually impaired people have always found difficulties in detecting the obstacles in front of them particularly during walking on the street, proving it to be dangerous. This project has been proposed as a solution for aiding these visually impaired or partially sighted people by developing an intelligent system. Information regarding the direction and obstruction detection would be provided to the user, this would be done by using ultrasonic sensors, a vibrator motor, and a buzzer. The intensity of the vibration would increase or decrease with respect to whether the detected object is closer or farther. Moreover, the system would provide a Mobile Application interface which would be designed to be connected by the hardware module and would help perform various tasks without the user ever touching the mobile phone. The mobile application would accept voice commands from the user to perform various tasks. The tasks would include telling the user's current location and aiding the user to go to the desired destination. This whole system would be activated by voice commands. The proposed system would be designed to be compact and would weigh less. The module would be incorporated with the cane, making the visually challenged persons walk with more confidence and independence. The system will provide safety.*

Key words--*Ultrasonic sensors, Buzzer, Vibrator Motor, Outdoor mode, Indoor Mode, Arduino Uno, Navigation Guidance, Obstruction Detection, Visually Impaired*

I. INTRODUCTION

One of the most important five senses, the Vision or Eyesight is extremely essential as most of the information humans get from the environment happens through the observation by sight. The World Health Organization reports that 285 million are estimated to be visually challenged and experience complete or partial loss of vision. Out of these, 246 million are partially challenged or experience low sight and the rest 39 million are at complete loss of vision. It has been proved that about 90% live at extremely under developed areas of the society. Vision loss is also seen very commonly in age group 50 and above. Blind persons are constantly experiencing imbalance in muscle and hand-leg coordination as there is no input signal to the brain via eyesight. Navigation guidance is the most fundamental function of a human being to gain independence and self- reliance. However, the visually impaired go through this lack on a regular basis.

A walking stick and a walking dog has been witnessed as the earliest form of navigation method for the completely blind. It suffers from a lot of limitations and drawbacks like extensive habituation, motion range, range detection and low reliability for dynamic hurdles. With the advancements in the technical world, it has become a reality to design and provide technological answers that can help a visually challenged person to navigate securely

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and independently.

II. STATE OF THE ART (LITERATURE SURVEY)

In past, various advancements have been made to help and assist the sightless personnel. There has been continuous increments in the modifications and specifications of such models. However according to these models, they are yet to be economically viable and user friendly. The recent proposed methodologies along with their limitations are discussed as follows:

Ultrasonic Sensor Based Smart Blind Stick [1]: A secure and protected walking stick was proposed using a PIC microcontroller 16F877A. Navigation was tested to be safe and sound. Detection ranges varied with a minimum of 5 cm and lasted till 35 cm. A buzzer was added for the benefit of the user. Author suggested the extension of the range in detection, voice commands and further assistance to be incorporated in the future.

Ultrasonic Blind Stick for Completely Blind People to Avoid Any Kind of Obstacles [2]: The system which is designed is used to detect various forms of the obstacles that lie ahead. This system uses the reflection characteristics of ultrasonic waves. To make the design more all-around and adaptive, it can be attached to shoes and clothing items. Can be customized to a walking stick as well. Limitations included, the accuracy being affected during temperature changes. Obstacle detection required a minimum thickness (3 mm) and distance (2 cm) to function properly. It was difficult to adapt in an external environment.

Wearable Navigation and Assistive System for Visually Impaired [3]: A robust result for the visually challenged is presented through wearable and portable devices which are assistive in nature. Moreover the research is confined to a prototype. Author expresses more comfortable and portable wearable gloves as its future prospective.

Blind navigation using ambient crowd analysis[4]: The research was demonstrated practically with real life implementations along with the well explained theoretical knowledge for the system. Author expressed Internet of Things to play a crucial and vital objective in the development of assistive systems for the visually challenged. System was checked for pedestrian detection using cheap noise elimination devices. Due to usage of camera, the system was economically not approachable to the backward sections of the population.

Smart Stick for the Blind and Visually Impaired People[5]: A device was developed to guide the sightless people through sensing and identifying the obstacles. This was achieved by the installed sensors. Vibrations were passed on to the user via the microcontroller to alert and caution the user of the hindrance. The system was not user convenient. Size, power source and cost emerged as the main reasons of the system's difficulty to be complied in everyday use.

A Hybrid Approach for Identification of Manhole and Staircase to Assist Visually Challenged[6]: This design acquired the feature of vector identification along with sensors developed using the Arduino kit. Stick was made to weigh less and encouraged the blind to reach their targeted area with comfort. The Gaussian mixture model with the decision module is used for faster identification of the interference. The modules are embedded in the stick.

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III. PRPOSED WORK

The proposed system is a cost effective solution which combines the hardware and mobile application to help better the user experience. Three ultrasonic sensors are placed on the stick, hereby referred to as sensor 2, sensor 3 and sensor 4. The functionality of these sensors is to detect obstacles. The range of each sensor is up to 200 cm in the front and captures 60 degrees of field view. These are henceforth situated in a form to encompass most the view for the obstacle. Another ultrasonic sensor, hereby referred to as sensor 1 is fixed at the bottom of the stick for pothole detection. The handle of the stick has a vibration motor which vibrates to let the user know about the obstacles ahead. Its intensity increases or decreases depending upon the closeness of the obstacle.

Besides the 3 ultrasonic sensors is a buzzer which rings to let the people surrounding the user know he is blind. Hardware part is also connected to a power source. The mobile phone is connected to the Arduino, the android application is installed in this mobile phone. This application finds its usage in pothole and obstacle detection via the mechanisms of voice, gesture identification and Global Positioning System (GPS) navigation. The application provides a seamless experience to user without user even touching the mobile phone.

A. Architecture Diagram

The figure shows the architectural diagram of the system. It gives a brief about how the sensors are connected. All the 4 ultrasonic sensors, vibration motor and buzzer are connected to Arduino. Battery is used as a power source for the system. The model is connected with mobile phone via USB cable (serial connection). The system can also get power supply through the mobile phones.

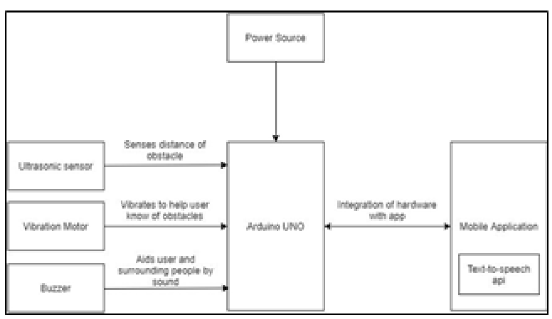

Figure 1: Architecture Diagram

B. Arduino and Sensors

Arduino Uno

The Arduino Uno enables the user to create reciprocated and interactive electronic systems. An open source microcontroller it is very commonly used in IOT projects. This microcontroller is very easy to program and allows to connect with mobile phones via serial connection using a USB cable.

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Figure 2: Arduino Uno

Ultrasonic Sensor

In this system HC-SR04 ultrasonic sensors is used. It is most common ultrasonic sensor which is readily available in market and is very cheap. This is a very common and prominent sensor used to sense objects and measure distances in various scenarios. Its range is from 2cm to 450cm.

The sensor works with the very well-known school formula: Distance = Speed × Time

Figure 3: Ultrasonic Sensor

Vibration Motor

Vibration motor is known to be extremely compact in size. It is a coreless DC motor which briefs the user of receiving vibrating signals without the use of sound. Here a simple DC 3V vibration motor is used. Its speed is 1100RPM. This type requires very less amount of power to run. This also has high efficiency. These are generally used in mobile phones and protection equipment.

Figure 4: Vibration Motor

Buzzer

Frequently found in household appliances and automotive machines, a buzzer is an electronic signaling device. This system uses very simple DIY buzzer which is very cheap and uses very less power.

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Figure 5: Buzzer

IV. IMPLEMENTATION

The implementation of project can be divided into three main parts:

A. Detection of Pothole

B. Detection of Obstacles

C. Mobile Application

A. Detection of Pothole

For detecting pothole, an ultrasonic sensor is placed at bottom end of the stick. It faces the downwards to the earth. To find out the distance, the sensor reads the time taken for the ultrasonic waves to bounce from the ground. Sound's Speed (sp) = 340 m/s Distance = (sp*time)/2

To discard the distance for sending the signal, it is divided by a factor of two as shown in the formula.First four values are recorded to calculate the threshold value. In order to detect potholes, each of the observed value is checked with the threshold value. This is done by comparing all of these new additional values which are picked up by the user on its path, with the threshold value. A threshold value is calculated by observing and recording the pattern of the user's way of handling the stick as the height of the person and stick's holding position differ from one individual to another. All this leads to the successful uncovering of the pothole in the path of the user. Certain specific limits are established to calibrate the threshold value as the system might get affected with the misjudgment of the user and can led to ambiguous results.The values pertaining to these limits are selected and added together to achieve an average value. Along with this average value, the largest recorded value of the set is noted. The average value gives the system an indication of the height the stick is usually lifted when walking on a path. The latter value on the other hand gives the greatest possible deviation when values are being calibrated. The maximum variation or a fluctuation value is given by the difference between these two values. This value is then multiplied by a factor of two and then added to the average value i.e. the error is considered as well. This gives the threshold value. The method adapted in this system improves the accuracy and consistency. It has also incorporated the largest recorded value for the greatest deviation possible.

avg_value= (addition of 4 values) / 4 max_value= maximum of initial 4 values fluctuation= max_value - avg_value threshold= 2(fluctuation) + avg_value

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By observing the readings of the ultrasonic sensors, the Arduino formulates the distance from the base, here that is the ground. The readings are calculated in each loop and the values are compared with the formerly calculated threshold value for pothole detection. Whenever a situation where the new reading is greater than the threshold is established, the possibility of a pothole is witnessed. The mobile application is designed to send a warning signal to the user when a pothole is detected.

B. Detection of Obstacles

At the middle of the stick there are three ultrasonic sensors which are used for detecting obstacles. The sensors are placed in such a way to increase the detection area. All the three sensors record the time elapsed in receiving the signal for obstacle detection. Thereafter the distance is formulated in the Arduino same as in pothole sensor, i.e. sensor 1. For this, the algorithm devised is as follows:

i. f_distance = distance received from the front sensor i.e. sensor 2

ii. if (f_distance>=100 && f_distance<=200)

a. alert that obstacle is ahead.

b. Go to (v.)

iii. calculate r_distance and l_distance which refer to the distance on right and left sensor respectively.

iv. if (r_distance<80 && l_distance>100) alert the user to turn left

else if (l_distance<80 && r_distance>100) alert the user to turn right else if (l_distance<100 && r_distance<100) alert the user that the path is blocked

else alert the user to turn anyway(left or right) go to (i.)

v. check f_distance again for closeness

vi. if (f_distance<100)

a. alert the obstacle very close and in the front

b. go to (iii.)

The result from this algorithm is then sent as a signal in form of a character to the mobile application. With the help of textto- speech in android, the output is generated in voice form.

C. Mobile Application

The mobile application is designed to provide further assistance to user. The user is alerted about the surrounding obstacles by reading and interpreting the various signals received from sensors. An alert message is read out loud to the user by using text-to-speech in android, whenever there is a pothole or an obstacle detection. The position of the obstacle is also given as an output to the user i.e. whether obstacle is on the left side or on the right side of the user or is in front of the user. The application also provides other functionalities like navigation. It can launch map service when the user wants to go to a particular destination, navigation starts when the screen is tapped twice.

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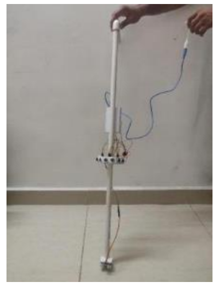

Figure 6: A snapshot of the implemented system.

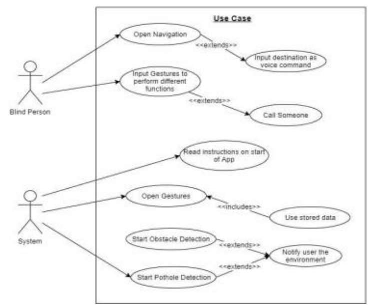

Figure 7: The use case diagram depicts the interaction of the user with the developed system.

The speech-to-text service is launched, where user can just say the name of the destination and the map service opens and the navigation starts. Application also has gesture recognition feature. Swiping left on bottom of screen launches the gesture recognition. User can just draw a particular pattern and application will do the functionality assigned to the gesture. For example some gestures are used for knowing the date and time and other will be used for calling a particular person or an emergency contact. Application will already have a list of emergency contacts stored.

V. RESULTS DISCUSSION

This proposed work led to an elucidation of navigation systems for the sightless. This was designed to aid the visually challenged personnel with help of multiple ultrasonic sensors. The system catered to the problems of different situations like wide area coverage for obstacle and pothole detection. This system was also incorporated with a userfriendly mobile application which increased the confidence of the sightless people to walk in a non-familiar environment.

Table 1: The table above depicts the navigation feature of the system.

Voice input for Destination	Command Recognized	Navigation Started	Result
"SRM Hospital"	"SRM Hospital"	Yes	Success
"Potheri Market"	"Lottery Market"	No	Failed
"Potheri Railway Station"	"Potheri Railway Station"	Yes	Success
"Zoho Corporation"	"Zoho Corporation Pvt."	Yes	Success
"SRM Lake"	"SRM Lake"	Yes	Success

Depending on the voice input commands the outcome of the navigation system is recorded.

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Table 2: The table above shows the output of pothole and obstacle detection modules along with the audio output that is generated on their presence.

Presence of Pothole or obstacle	Audio output	Result
Obstacle in the front	"Obstacle ahead"	Success
Pothole present	"Pothole detected"	Success
Obstacle in the front and on left side	"Turn right"	Success
Obstacle in the front	"Obstacle ahead turn anywhere"	Success
Pothole present	No output	Failed
In the front, on right side and on left side	"Path blocked turn back"	Success
In the front and on right side	No output	Failed

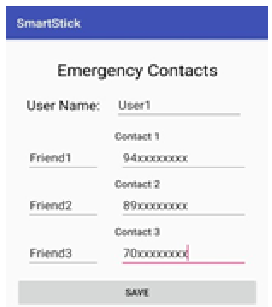

Figure 8: Snapshot of the Mobile App

VI. CONCLUSION

The thorough analysis of the research papers in the related fields gave a good grasp on the knowledge development in this area. It was decided to use Arduino Uno, Buzzer, Ultrasonic sensors and Vibrator Motor. A user friendly Mobile Application has been formulated which would be fully voice operated. The improvements have been reflected in the parameters of range and operability. Real life implementations and practicality of the project was obtained as the developed system was economically feasible to the larger sections of the population.

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