IoT Based Smart Walking Cane For Typhlotic with Voice Assistance

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***Abstract*—Locomotion is inevitable for human beings. The main problem for visually challenged is movement from one place to another, level crossing and identification of their current location. In case of their venture into unfamiliar environment it is a menace for them and for their fellow mates too. Therefore it is essential for the family members, organization of visually challenged to know the current location of the visually challenged. Smart walking cane acts an Electronic Travel Aid (ETA). Smart walking cane solves the challenge by detecting both indoor and outdoor obstacles and by providing level crossing guidance and current position of the visually challenged. Obstacles are detected using Ultrasonic sensors; Global Positioning System (GPS) is used to indicate the current location of the visually challenged; level crossing guidance is provided by Reflective Infra Red (RIR) sensor. The current position of visually challenged is uploaded to cloud through Wi-Fi module. Navigation information and instructions is intimated to the user of the Smart walking cane by text-to-speech converter through stereophonic Headphone. Buzzer and Vibratory circuit assists to find the distance in noisy environment too. This Smart walking cane meets the mandatory requirements of the blind people to navigate as well as to know the position and orientation of the visually challenged.**

***Index Terms*-ETA, GPS, RIR, Ultrasonic Sensor, Wi-Fi, Travel Aid for the Blind.**

I. INTRODUCTION

Artificial Vision is the most important part of human physiology as 83% of information human being gets from the environment is via sight. Mobility of visually impaired people is restricted by their incapability to recognize their surroundings. Over 39 million people were totally blind out of which 19 million are children (below 15 years). Over 90 percent blind children obtain no schooling. Recent survey says, India has become the country with large number of blind people. The population of India has reached 120 crore of those 8.90 crore people are visually impaired and among them 90% cannot travel independently [5]**.** Mostly visually challenged use *white cane* or *Guided dog* which is not a permanent aid to them. If a guided dog is used the person can go to the places where the dog is trained to move. It is an additional burden for visually challenged to take care of a dog [8]. Advancements in Technology is a scintillation to the visually challenged people. A lot of work is being done in the field of electronics in developing navigation aids for visually challenged people [10],[14]. Motion Sensor is used to alert the user of the smart walking cane about the current traffic status and guide the user to cross the asphalt. Ultrasonic sensor is used to detect the obstacle distance [3]. Ultrasonic sensor is used because of its ability to detect all kinds of obstacles irrespective of whether the obstacle is metallic or non-metallic, colored or non-colored, wet or dry. The dust particles in wind, moisture doesn't affect the working of ultrasonic sensor. Global Positioning System(GPS) is used to intimate the user regarding the current position along with time [6]. Current location is not only intimated to the user but also to his fellowships through Wi-Fi module. Text to speech converter reads out the words fed to it to the user which would be very helpful for a visually challenged [4],[13]. The following sections discuss the features of this Smart walking cane. Section II presents System architecture. Section III discusses obstacle, distance and staircase detection. Pedestrian level crossing guidance in presented in Section IV. Position Locator in Section V, intimation to the visually challenged in section VI followed by Results and discussions in Section VII and conclusion in section VIII.

II. SYSTEM ARCHITECTURE

Figure 1 shows complete physical model of the Smart walking cane . The Ultrasonic Sensors are kept at five different heights to recognize obstacles at different positions. First Ultrasonic Sensor facing downwards is to find the pit while walking. The Ultrasonic sensors are kept at heights of 10,25, 40 and 75 cm to recognize the obstacles of different heights. Specially programmed text to voice converter informs the obstacle information to the user through stereophonic headphone. The frequency at which the buzzer buzzes alerts the visually challenged regarding the obstacle distance and make the people around the user of the Smart walking cane realize that visually challenged is around them . Motion sensor senses the movement of any vehicle in the sensing region and informs the user of the same. The Vibratory circuit is used to assist deaf people in navigation. The GPS Module senses the current location of the user and the Wi-Fi Module transmits the current location to the cloud, where the user navigation history can be tracked. All the above mentioned functionalities are controlled by a microcontroller that is programmed to continuously monitor the input from various sensors connected to it.

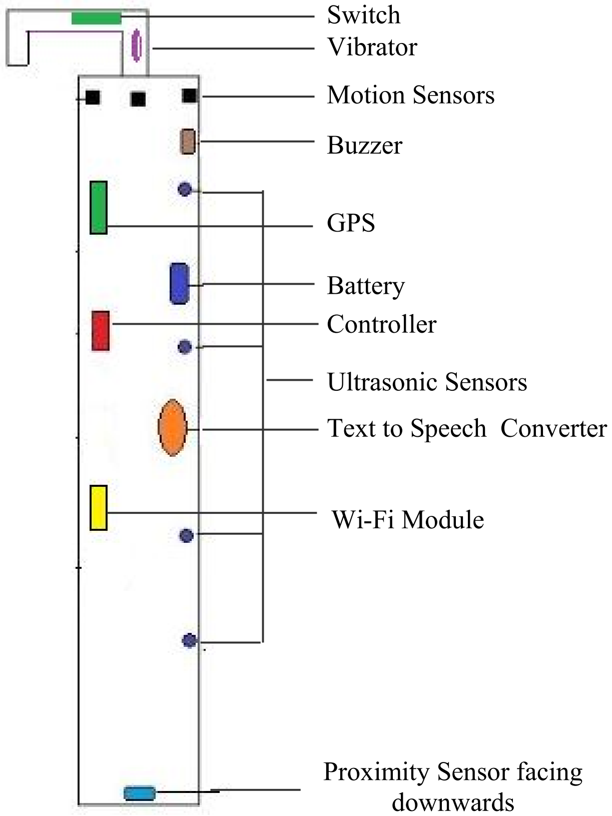


Fig. 1. Overall view of stick

III. OBSTACLE DETECTION

A. Working of the sensor

Ultrasonic ranging module HC - SR04 provides 2cm - 400cm non-contact measurement function, the ranging accuracy can reach to 3mm. The module includes ultrasonic transmitters, receiver and control circuit. It operates at a supply of 5V and 15 mA [7].The IO trigger of the sensor is set high for at least 10µs . The Module automatically sends eight 40 kHz and waits for the pulse signal to be received back until the signal is received back it maintains its high level. If the signal is received back it switches to low level. The time of being at high level is called high level time. Figure 2 shows the ultrasonic sensor used in the Smart walking cane.

Fig. 2. Ultrasonic sensor

Distance = (high level time × sound velocity)/2
Velocity of sound = 340-350m/s (15°C to 30°C)
Distance in cm = Distance/58;

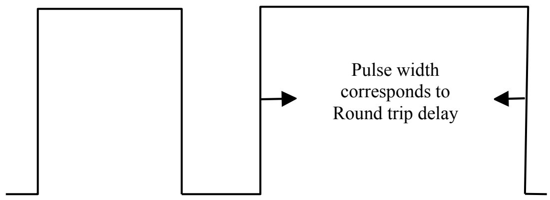


Fig. 3. Output wave of Ultrasonic Sensor

B. Detection of pits and staircase

The ultrasonic sensor facing downwards is used to detect a pit and also to assist in climbing up and down stair case [1]. Four ultrasonic sensors facing straight is used to detect the obstacles and staircase ahead of them. The sensors are placed at the height of 10 cm, 25 cm, 40 cm and 75cm from the ground. If the first three sensors detect obstacles at increasing heights with increasing distance, there is a possibility for presence of staircase. These three sensors detect the first three steps and by the time the user had climbed up those steps it would have detected the next three steps. If all the four sensors from bottom to top of the stick give a reading in the increasing order especially the first three sensors then the voice information to the user is *"Staircase ahead"*. If a sudden fall in walking surface of depth of 10cm is detected then there is a possibility for it to be a down stair case.

C. Detection and intimation of obstacles at different heights

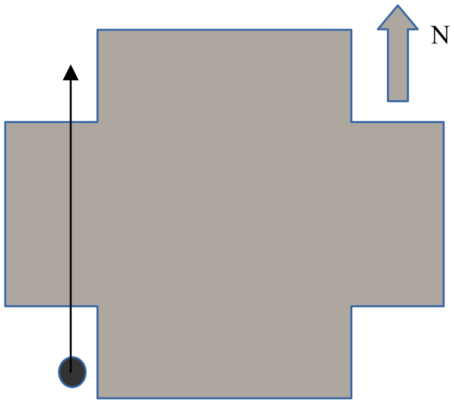
The height of the obstacle can be detected from the position of the sensor in the stick with respect to ground. If there is a obstacle at a height of 13 cm at a distance 17cm from the sensor, then only the sensor placed at 10 cm from the ground will intimate the micro controller that a obstacle is being detected by it. So the information to the user is *"There is obstacle at a height less than 25 cm at a distance of 17cm before you"*. The sensor which is at a height of 25 cm doesn't detect any obstacle, so the height of the obstacle must be less than 25 cm. Consider another case where the obstacle is of height greater than 80 cm at a distance of 35 cm from the stick. In this case all the sensors will detect there is a obstacle before it. So the intimation to the user will be *"There is a obstacle of height greater than 75 cm at a distance 35 cm from you"*, since the sensor at height 75 cm has detected the presence of a obstacle there is possibility of obstacle to be of height greater than 75 cm.

Consider another case of wall mounted steel cupboard of width 30cm at a height of 70 cm from ground at a distance of 20 cm from the stick. In this case all the sensors that are placed at heights of 10 cm, 25 cm,40 cm will sense the wall as the obstacle but the sensor placed at the height of 75 cm will sense the cupboard as the obstacle so it will intimate the controller that the obstacle is at a distance of 20 cm from it but all the other sensors will inform the controller that the obstacle is at a distance of 50 cm from it since the wall is at 50 cm from the stick. In this case the guidance to the user will be "*There is obstacle of height greater than 75 cm at a distance of 20 cm from you*". The intimation to the user will be regarding the obstacle that is at least distance from the user.

IV. Pedestrian Crossing Guidance

A. Motion sensor assistance in pedestrian crossing

Before Reflective Infra Red (RIR) motion sensor has been used to detect the motion of objects. Infrared rays are emitted. Depending upon the sequential reception of infrared rays in the two sensing elements the motion of object has been detected. One has to cross the road only when the green signal is on i.e. only when the vehicles from his side moves to the opposite side. This logic is used to guide the visually challenged to cross the road using motion sensor



● Indicates position of Visually challenged in a 4 Junction Road

Fig. 4. Visualization of level crossing

Consider a visually challenged standing in the south-west of the four road junction as indicated in Fig. 4. If the user wishes to move to his opposite side that is north. The visually challenged has to cross the road only when the vehicles from his side moves to the opposite side.

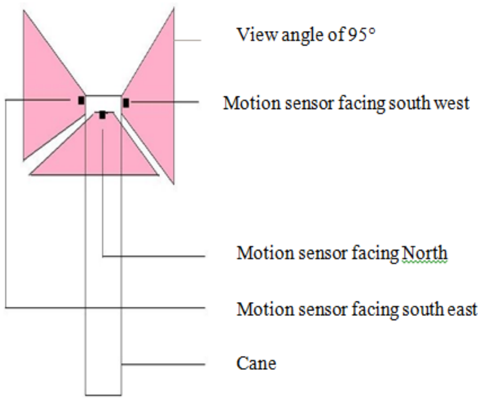


Fig. 5. Position of Motion Sensor in Stick

The motion sensor has a view angle of 95 °.So three motion sensors each positioned at right, left and front side of the stick has been placed so it totally covers an angle of 285°. If the user holds the stick facing north then the sensors faces southeast, southwest and north directions respectively. As the user has to hold the stick the remaining angle is concealed by the user. In the above mentioned case as the vehicles from south moves towards north the sensor facing southeast direction will detect the motion and informs the controller which in turn informs "It is safe to c*ross the road*".

Another possibility is that, since it is four roads junction the vehicle may also move from south to south west direction. In such a case it becomes a menace for the visually challenged. So the right time for the visually challenged to cross the road is only when the sensor facing southeast detects the motion and not by the sensor facing north. If sensor facing north detects motion then the guidance to the visually challenged will be," *Not safe to cross the road*".

V. Position Locator

A. Position Identification and upload to Cloud

Smart walking cane not only support the visually challenged in navigation but also in detection of the current location and it updates the location to cloud. It is of ultimate importance to know about the current position of a person. In order to solve this challenge Global Positioning System (GPS) is used [9]. The current position along with current time can be found using GPS which triangulates the GPS data received from three or more satellites [2] as shown in Fig. 6. The data provided by GPS is processed by microcontroller and voice information is informed to the user through stereophonic headphone [15].

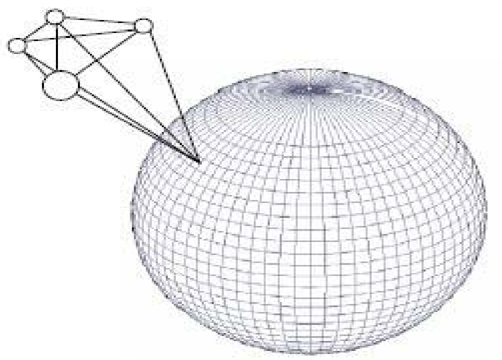


Fig. 6. GPS collecting Information from four satellites

The current location of visually challenged is not only important for them but also to their fellowships. They should be aware of the visually challenged person's current location because there is a possibility that a visually challenged ventures into an unknown environment. It is the responsibility of the fellowships to find the visually challenged if they are lost. So it is essential to keep track of their path. Wi-Fi module is used to upload the current position of the user of the Smart walking cane to cloud. The fellow mates, organization for blind people can access the web page with the login ID provided to them. Separate login ID will be provided for each user of the stick. So at any time the fellowships can track the position of the visually challenged.

VI. Intimation To The Visually Challenged

A. Text to Speech Converter

The guidance to the user is done using Text to speech converter module. The text to speech module intimates the user of obstacles at different heights and distances [11] and can convey information in multiple languages. It has a inbuilt headphone socket. The information can be provided to the user via stereophonic headphone.

B. Buzzer

Buzzer is used to convey the information to the user of presence of obstacles at different distances by beeping at different time intervals for different distances. It also alerts other people if they are about to collide accidentally with the typhlotic who uses the Smart walking cane.

C. Vibratory Circuit

Vibratory circuit helps the deafblind people to walk through the obstacles safely . Different intensities of vibration indicates obstacles at different distance [12]. The intensity of vibration increases as the user move close to the obstacle.

VII. Results And Discussion

The prototype of Smart walking cane has been implemented and the results are tabulated and charted. Buzzer is used to intimate the user with its beep sound differing by intervals between the beep sounds. The following Graph shows variations in intervals of beep sound for different distance of obstacles.

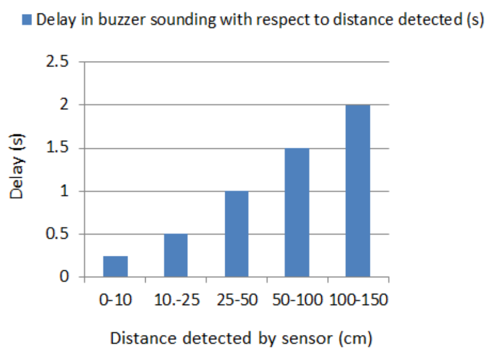


Fig. 7. Variation Of Intervals in beep sounds

Five ultrasonic sensors are used for detecting obstacles where one ultrasonic sensor is used for depth measurement which is shown as 1 in the Table I and other four ultrasonic sensors which is mentioned as 2,3,4 and 5 in the Table I are used for measuring obstacles at different heights in the increasing order. Sensor 1 is given higher priority since it detects sudden fall in height of the walking surface. Only when sensor 1 does not detect any sudden pit, other four sensors are triggered since the detection of sudden fall in walking surface is of more importance than detecting the obstacles.

The GPS data received using the GPS module in NMEA format is decoded to get latitude and longitude values and traced on Google Maps to identify the path travelled by the user. Figure 8 shows the GPS data plotted on Google Maps.

Wi-Fi module is used to upload the GPS data to be plotted on the Google maps. Figure 9 shows the GPS data uploaded to cloud by the Wi-Fi module is plotted as a line chart and the variation in longitude with respect to time .

TABLE I. Results of Navigation Assistance Using Text to Speech Converter

S.No	Sensors	Readings(cm)	Intimation
1	1 2 3 4 5	7 18 52 35 90	Obstacle at 18 cm at height less than 25 cm
2	1 2 3 4 5	16 - - - -	A pit of height 16cm is ahead of you.
3	1 2 3 4 5	9 68 75 80 20	Obstacle at 20cm at height greater than 75cm
4	1 2 3 4 5	24 - - - -	A pit of height greater than 20cm is ahead of you
5	1 2 3 4 5	9 43 61 38 66	Obstacle at 38cm at height less than 75 cm

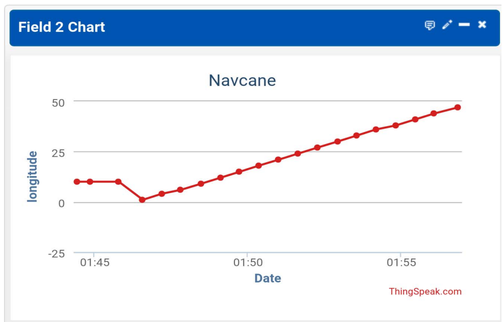


Fig. 8. GPS data uploaded to Thinspeak using WI-Fi module

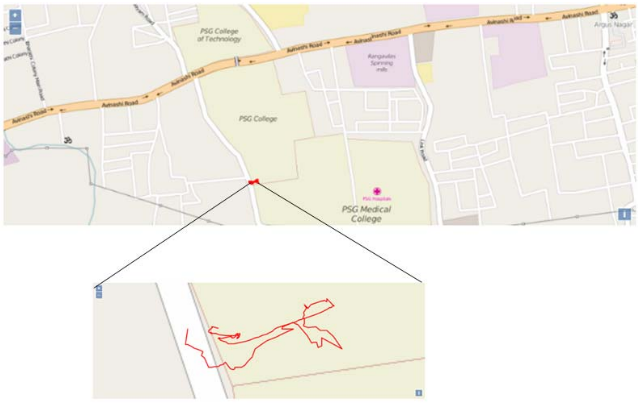


Fig. 9. Decoded and traced GPS Data

Figure 10 shows the working model of the stick which is built as a prototype.

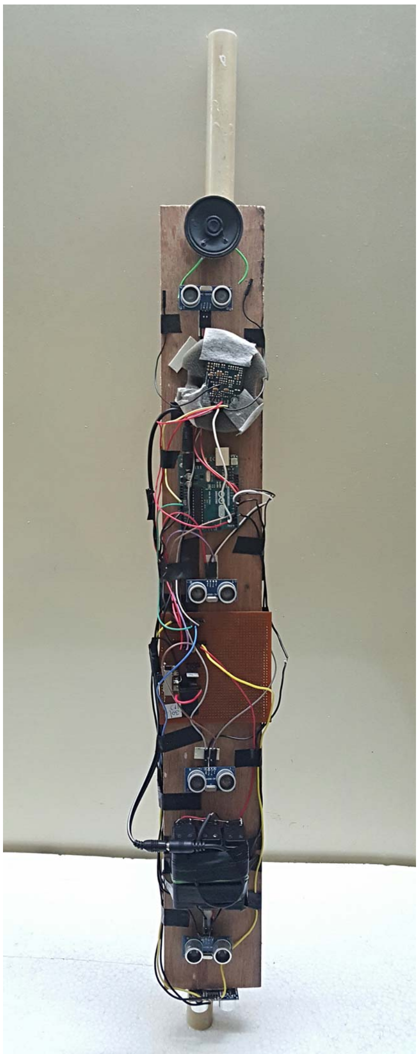


Fig.10. A working model of Smart walking cane

VIII. CONCLUSION AND FUTURE WORKS

Although certain limitations like the inability to detect the obstacles hanging at a height of 150 cm from the ground exists, this model proves to be a great scintillation to the lamented visually challenged people. Its low cost of Rs.9000, weight around 2 Kg proves to be a great luminance to the visually challenged with its augmented features compared to already existing white cane and guided dog. In future, the suggestions that are got from the blind people who made an experimental use of the Smart walking cane are to be updated in the Smart walking cane.

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