

An Intelligent Walking Stick for the Visually Challenged People

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Abstract

In this high tech era, technology has made it possible that everyone can live a comfortable life. But somehow the physically challenged people need to depend upon others in their daily life which ultimately makes them less confident in an unfamiliar environment. But nowadays the explosion of innovative technology provides many opportunities for them to live confidently without feeling as a burden. So, in this paper, an intelligent device is represented for visually challenged people to guide them to reach their destination place safely without facing any difficulties. It consists of Raspberry Pi and PIC as the controller, Global Positioning System (GPS) along with sensors like Ultrasonic and other supportive sensors and an Android-based Application (APP).

Key words: Intelligent device, Raspberry Pi, PIC, Ultrasonic Sensor

I. Introduction

Vision is a precious gift from God that one can able to see and enjoy this beautiful world. But many people throughout the world are deprived of this. According to October 2017 report of World Health Organization (WHO) an estimated 253 million people live with vision impairment: 36 million are blind and 217 million have moderate to severe vision impairment. Un-operated cataract is the main reason for blindness in low income and developing countries [9]. So, in this case most of the visually challenged people cannot afford an expensive device to use as their supporter. So, in this paper we have proposed a cost-effective intelligent device. This device mainly consists of a walking stick and an APP. The walking stick is based on the integration of sensors which helps to detect obstacles in their path. A GPS module is also used to know the location of the blind person. For this, an APP is created, which makes them feel safe and secure because it helps in navigation as well as the relatives of blind person can also able to track their real-time location. Also in an emergency condition the blind person can contact his guardians immediately.

In early days the blind persons used trained dog to guide their path which is costly as well as not so efficient. Again the traditional white cane is only able to detect objects by touch, so it has also limitations to get less time to react the situation after detecting an obstacle [8]. There are many other mobility aids known as electronic travel aids (ETAs) in the market. But most of the commercial ETAs are expensive and lack of accuracy.

1. C-5 Laser Cane

It was introduced in 1973 by Benjamin [1]. Its working based on optical triangulation with three laser diodes and three photodiodes as receiver. The Laser Cane able to detect obstacles at head-height, drop-offs in front of the user, and obstacles up to a range of 1.5 m or 3.5 m ahead of the user.

2. The Mowat Sensor

It is a hand-held ultrasonic-based device that informs the user of the distance to detected objects by means of tactile vibrations [1]-[2]. The frequency of the vibration is inversely proportional to the distance between the sensor and the object.

3. Sonic Path Finder

It alarms the blind when detecting the obstacle by the acoustic difference. However, it does not provide the accurate path and the position of an obstacle [1]-[2].

4. Meldog

It uses the artificial intelligence, unlike in the sonic pathfinder [3]. It can provide the accurate position of an obstacle using the ultrasound and laser sensors [4]. But practically it is relatively bulky in size and heavy.

The above ETAs have some limitations that

- The user must actively scan the environment to detect obstacles (no scanning is needed with the Sonic guide, but that device doesn't detect obstacles at floor level). This procedure is time-consuming and requires the traveler's constant activity and conscious effort.[1]
- In these ETAs GPS is not used. So, no facility to find the locations of the blind person.

5. RFID based device

Several studies reported that RFID is the most accepted technology among the blind person. In particular, Ashwini B Yadav & co-workers reported that with the help of IR and RFID technology the visually impaired person find their way bypassing every obstacle and help them to cross the roads. For this the IR receiver needs to install on the lighting pole [13]. The Mohammad F Saaid & co-workers reported that the RFID tags need to be placed in the center of sidewalks with a certain distance to each other [14]. But the major limitation is the chance of getting interfere with the frequency of traffic light and also is very expensive to build such a system.

II. Proposed System

To overcome the certain limitations of existing devices we have proposed this intelligent device. Main objective of this paper is to make a light weight, affordable, intelligent ETA but not complicated which will be easy to carry by visually challenged people. The proposed device is a system integration of both software and hardware. Mainly it comprises an

intelligent walking stick and android based application (APP). The block diagram of the proposed system is shown in Fig.1.

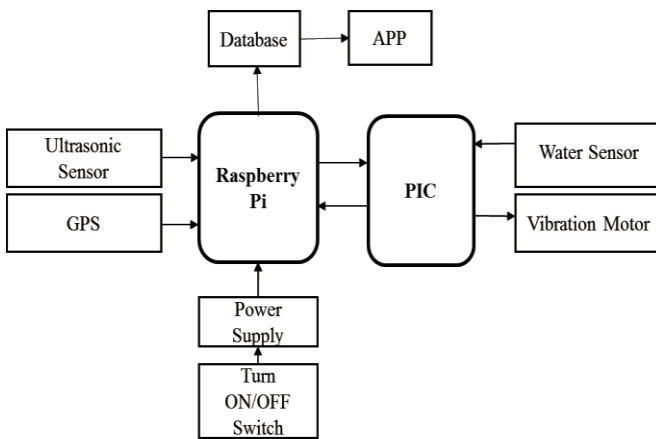


Fig. 1 System block diagram

The walking stick is based on sensors. The Ultrasonic sensor is used to detect the obstacles. As the bat get information about its prey by echolocation with the help of returned echoes of produced sound by itself, the same process has been applied to detect the obstacles. After detecting an obstacle, it is controlled by the controller. Here Raspberry Pi and PIC, two controllers are used as Master and Slave controller respectively. As the obstacle is detected, Raspberry Pi gives the command to PIC through I2C communication to create an alert.

Components used in this system:

A. Raspberry Pi

Raspberry Pi is basically a credit card sized computer which can be used in making many electronics projects. Because it can provide many facilities like Wi-Fi, Bluetooth, audio-video, I/O pins etc. In this project, we used Raspberry Pi Zero, due to its reduced size as half the size of model A+ with twice the utility [10] and also able to accommodate various peripherals at the same time, characteristic of low power consumption, and flexibility to work with different components [5].

B. Programmable Interrupt Controller (PIC18F4525)

In this project an advanced microcontroller is equipped with Raspberry Pi to increase the response speed and to decrease computational complexity. The program stored in the memory of the PIC is executed and make the vibration motor vibrates when it gets command from the master controller Raspberry Pi after detecting obstacles [6].

C. Ultrasonic Sensor

In this project SRF08 Ultrasonic range finder is used to detect the obstacles. The SRF08 interfaces to raspberry pi through I2C bus. The human's audible range of sound frequency is of around 20HZ~20KHZ. Ultrasonic is the sound above the human's audible range and is not harmful to human being. The transmitter of Ultrasonic sensor always sends a signal to its surrounding area. Then if the Ultrasonic Receiver will receive the same signal after reflection, it means the ultrasonic sensor has detected an obstacle. Then the distance between the ultrasonic sensor and the obstacle can be calculated from the total time taken by the signal to get transmitted and returned back. The reason to use SRF08 as obstacle detector:

- It can able to detect obstacle from a long distance which approximately ranges from 3cm to 6m. So, it is good that the blind person can get enough time to avoid the collision.
- The SRF08 can able to detect obstacle in front of it as well as in a conical shape of 45 degrees.
- It can able to detect almost any objects that have the property of sound reflection such as metal, non-metal, transparent or colored and liquid.

D. Water Sensor

The water sensor detects small puddles or moist surface on the walking path. Here Funduino Water level sensor is used.

E. Vibration Motor

It is a small size coreless DC motor used to alert the user by producing vibration. Here the coin type vibration motor is used. The vibration motor is used in consideration of a blind as well as a deaf person. Otherwise, the blind person can be intimidated by voice message through the earphone.

F. Global Positioning System (GPS)

GPS is a satellite-based navigation system owned by the United States Government. It was launched for military purpose but later it was allowed to civilian as well as commercial users. GPS works in any weather conditions and anywhere in the world. It provides location and time information to the user for free of cost who has GPS receiver. There are 30 satellites orbiting the earth twice in a day in which minimum 4 satellites are visible at a time [7]. The signal transmitted by the satellites is received by the receiver and allow the GPS devices to find latitude and longitude of the location. In this project u-blox NEO-6M GPS module is used.

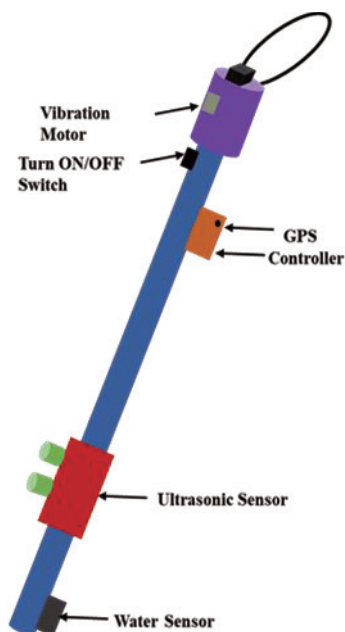


Fig. 2 Design of proposed walking stick showing the components used in the system

III. System Execution

It is a Raspberry Pi and PIC based intelligent walking stick with low power consumption. This walking stick is an

electrical and electronics based project interfaced with an Android based application which has been designed for the visually challenged people to help them in guiding their path as well as giving the information about their location. Fig. 4 explains the working of the whole system. When the switch is turned ON, it will start power supplying to Raspberry Pi, thus all the other components connected to stick also get power. Then the system starts to work. To detect obstacles the transmitter of ultrasonic sensor transmits ultrasonic wave repeatedly. So if an obstacle is encountered by the ultrasonic sensor in between the range of ultrasonic wave, then this wave bounces back and received by the receiver of ultrasonic sensor as echo wave. This result indicates that obstacle is detected. Then the distance between the user and obstacle is calculated by the ultrasonic sensor and send this value to Raspberry Pi. According to user requirement, a threshold value is set in the Raspberry Pi programming to alert the visually challenged people. The threshold value is a predefined distance range which can be changed. In this project, the threshold value is taken as 100 cm. Then the calculated distance (d) will be compared with the threshold value. If d is less than or equal to the threshold value then the Raspberry Pi will send this information to PIC and give a command to create an alert. Thus the vibration motor will start to vibrate and indicate the user about the obstacle. So, the blind person can change its direction avoiding the collision on his/her way. To make smoother walking a water sensor is also used. So it will help the blind person detecting small puddles or spill and slippery surface to avoid sliding.

Other than obstacle detection components a GPS module is used which helps in navigating, positioning and in real-time tracking. The GPS receiver receives a number of arrays of data from the satellites. The GPS module matches with a minimum of 4 satellites. It is interfaced with the Raspberry Pi and gives output in NMEA format. The NMEA message is in the form of an ASCII message string consisting of geospatial location, time and other relevant information [5]. The NMEA consists of many sentences with different data types like GPGGA, GPGSA, GPGSV, GPGLL, GPRMC, and GPVTG. In this project, GPRMC string is required. Hence a program is written only to get GPRMC string, out of which it can select the latitude and longitude and convert it into the required form. One of the real data of this project receiving by GPS receiver is shown in Fig.3.

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$GPRMC,130457.00,A,2502.04075,N,12123.45152,E,1.064,218.30,011217,,,A*62,25.034012,121.390862
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Fig. 3 GPS output in NMEA format

Where,
\$GPRMC - Recommended minimum specific GPS
130457.00 - Coordinated Universal Time. Here, it is 13:04:57 UTC
A - Signal status, A=Active or V=Void
2502.04075,N - Latitude,N - Northern hemisphere
12123.45152,E - Longitude,E - Eastern hemisphere
1.064 - Speed in knots
218.30 - Track angle
011217 - Date in DD/MM/YY. Here, it is 1st of December,2017

*62 - The checksum data [11]-[12]

If we will use the latitude and longitude shown in the first line of the Fig.3 directly then it will not show the correct location.

So, a program is written to convert it automatically into the appropriate form and will display in GPRMC string which is shown in the second line of Fig.3. It can directly use and show the exact location. Then these coordinates will be sent to the

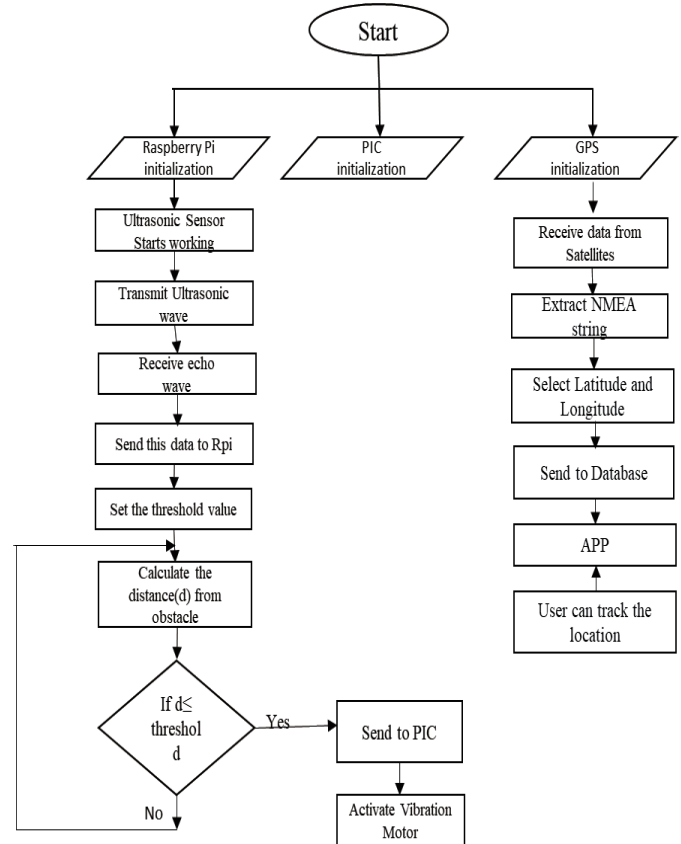


Fig. 4 Flow Chart of the whole system

database automatically to store for future purpose. These coordinates are used in APP. So that the users can able to know their position and also it is useful to track the users by their parents.

IV. Results

A. Obstacle detection

The system has experimented inside our campus and the result is found that the obstacles are detected in time. Because the difference between the real and recorded distance varies only 2 to 3cm as shown in Fig. 6. As threshold distance is set at 100 cm, the obstacle is detected before threshold value and the user was informed to react the situation in time as shown data of obstacle detection in Fig.5. Thus the blind person can move independently avoiding the collision.

B. Location tracking

An Android-based Application is created using Android Studio to get location information of the user. The APP has two functions, one is for the user and another one is for his/her parents/guardian. When the user will open the APP, first it will show the user location. Then the user will give his destination location as voice input. Then the Google map in APP will show the direction towards his destination in voice instruction. This function will help the visually challenged people to reach his destination location safely and easily. For this APP an unique user ID will generate for the first time users and this ID will be

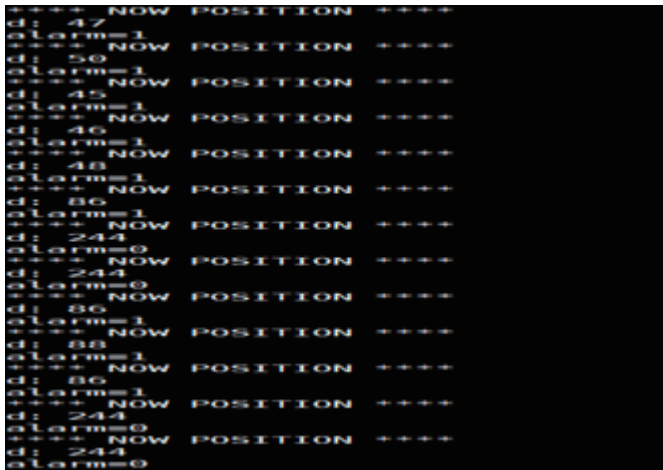


Fig. 5 Results of obstacle detection

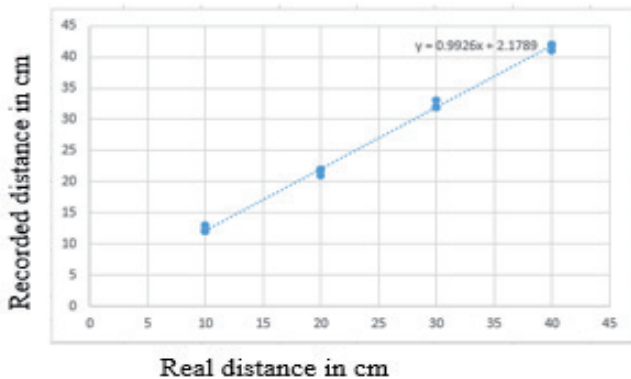


Fig.6 Comparison of distance between real value and recorded value

shared with their parents. This is because, if more than one user will use this APP then there will be no confusion for their respective parents to find their children location. So, when the parents will log in to APP, they need to give that user ID. Then they can track the real-time position of that particular user. So, there is no fear of being lost for the blind person and this makes them feel secure.

C. In panic situation

In an emergency condition of the user, message can be sent to preregistered contact by shaking the user's cell phone. For this the user needs to save his/her own and guardian's mobile number in the APP.

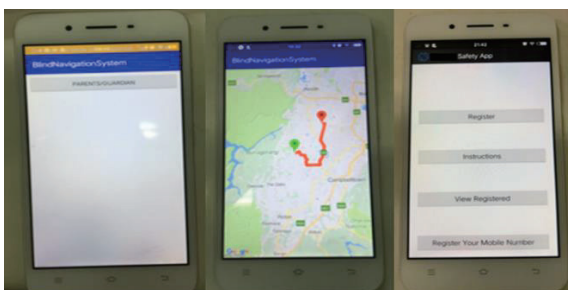


Fig.7 APP demo for navigation & Panic situation

V. Conclusion & Future Work

In this paper we proposed an intelligent system comprising a walking stick and APP for visually challenged people to

make them comfortable in their daily life. From the experimental results, it is observed that the system is capable of delivering the nearly exact distance measurement and can avoid collision accurately. The created APP is useful to reach the user's destination place safely and independently and also to track their location by their parents. Mostly to reduce cost and complexity, we have tried to use less electronic components in the project, thus it is quite lighter in weight and also affordable. So, it is easy to carry and use by the user. Consequently we want to collect data from surrounding environment and data analysis will be done based on neural network learning algorithms to predict any dangerous situation encountered by the blind person so that it can be avoided in time by taking the correct decision.

References

- [1] Johann Borenstein and Iwan Ulrich, "The Guide Cane-A Computerized Travel Aid for the Active Guidance of Blind Pedestrians," *IEEE International Conference on Robotics and Automation*, Albuquerque, NM, Apr. 21-27, 1997.
- [2] Zul Azizi Hailani, Sakinah Jamaludin, "An Electronically Guided Walking Stick for The Blind," *2001 Proceedings of the 23rd Annual EMBS International Conference*, October 25-28, Istanbul, Turkey
- [3] Susumu Tachi, Kazuo Tanie, Kiyoshi Komoriya, Minoru Abe, "Electrocutaneous Communication in A Guide Dog Robot (Meldog)," *IEEE Transactions on Biomedical Engineering*, 7 July 1985.
- [4] Sung Jae Kang, Young Ho, Kim, In Hyuk Moon, "Development Of An Intelligent Guide-Stick For The Blind," *IEEE International Conference on Robotics & Automation* Seoul, Korea, May 21-26, 2001.
- [5] Sudeep Gupta, Ilika Sharma, Aishwarya Tiwari and Gaurav Chitranshi, "Advanced Guide Cane for the Visually Impaired People," *2015 1st International Conference on Next Generation Computing Technologies (NGCT-2015)*, Dehradun, India, 4-5 September 2015.
- [6] Amjed S. Al-Fahoum, Heba B. Al-Hmoud, and Ausaila A. Al-Fraihat, "A smart infrared microcontroller-based blind guidance system," *Act. Passiv. Electron. Comp.*, Vol. 2013, 2013.
- [7] Anushree Harsur, Chitra.M, "Voice Based Navigation System for Blind People Using Ultrasonic Sensor," *International Journal on Recent and Innovation Trends in Computing and Communication*, Vol. 3, no. 6, pp. 4117-4122, 2015.
- [8] R. Bhambare, A. Koul, S. Bilal and S. Pandey, "Smart Vision System for Blind," *International Journal of Engineering and Computer Science*, vol.3, no. 5, pp. 5790-5795, 2014.
- [9] World Health Organization, <http://www.who.int/>
- [10] Raspberry Pi Zero, <https://www.raspberrypi.org/>
- [11] <http://aprs.gids.nl/nmea/>
- [12] <http://www.toptechboy.com/arduino/lesson-24-understanding-gps-nmea-sentences/>
- [13] Ashwini B Yadav, Leena Bindal, Namhakumar V. U, Namitha K, Harsha H, "Design and Development of Smart Assistive Device for Visually Impaired People," *IEEE International Conference On Recent Trends In Electronics Information Communication Technology*, May 20-21, 2016, India.
- [14] Mohammad Farid Saaid, Ismarani Ismail, Mohd Zikrul Hakim Noor, "Radio Frequency Identification Walking Stick (RFIWS): A Device for the Blind," *IEEE 5th International Colloquium on Signal Processing & Its Applications (CSPA)*, 2009.