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Advanced Guide Cane for the Visually Impaired People

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***Abstract*—This paper focuses on developing a new type of cane for the visually challenged and blind. This advanced guide cane will help the visually challenged person navigate both indoors and outdoors. This cane consists of an obstacle detection system as well as GPS navigation system. The GPS navigation system works only outdoors while the obstacle detector system works everywhere. Both these systems provide a series of audio feedbacks to aid the user. The systems are attached to a walking stick, and are portable and light weight. The advanced guide cane is powered by a rechargeable source and consumes low power. The GPS navigation system is pre-programmed to help the user navigate in the area of his/her choice. The project uses Raspberry Pi, which enables ease of programming and integration of the two systems in our cane.**

Keywords: Guide Cane, GPS, Obstacle Detector, Raspberry Pi, Audio Feedback .

I. Introduction

Assistive devices are a key aspect in wearable systems for biomedical applications, as they represent potential aids for people with physical and sensory disabilities that might lead to improvements in the quality of life. This project is aimed at making a product that can be easily used by any visually impaired person to navigate easily and safely. The ever increasing number of visually impaired people in India as well as across the globe has attracted our concern to practically implement our technological knowledge for a social cause. Visually impaired people have a difficult time self-navigating outside the well-known environment. Traveling or simply walking down a crowded street may prove to be a great difficulty for them. Therefore they need constant support to help them navigate. Even inside their house, visually impaired people have to learn about every obstacle present such as tables, chairs and shelves. This project is aimed at developing the system to address these problems: (i) Obstacle detection using ultrasonic sensor and (ii) easy navigation for an outdoor environment using GPS receiver. Most of the disabled are poor also so our cane can be used by the poor also[1][3].

The primary objective of this work is to design a small and easy to use navigation device to help the blind people to gain environmental information as voice message using GPS technology. For collision avoidance ultrasonic sensor are also placed on the stick to detect obstacles in front and above waist height. The storage capacity of voice recorder used in earlier system [14] is very small with playback ability of 40-60 seconds whereas with Raspberry Pi it is extended and can be chosen as per blind users choice.

The rest of the paper is organized as follows: Section II discusses the components used for navigation and obstacle detection. The methodology used is discussed in Section III. Section IV contains experimental tests and results and Section V includes a conclusion of the proposed work and future work.

II. System Description

The advance guide cane for the visually impaired has two systems which work in parallel. The two systems are obstacle detection system and GPS Navigation system. These systems are controlled by Raspberry Pi.

A. Raspberry Pi

Raspberry Pi is used as the processing unit. Raspberry Pi is a low-cost, basic computer. The Raspberry Pi is contained on a single circuit board roughly the size of a credit card. The computer runs entirely on open-source software and gives students the ability to mix and match software according the work they wish to do. It was chosen for this project due to its ability to accommodate various peripherals at the same time, low power consumption, small size and flexibility to work with different components. It can be easily programmed using Python. Hence, both our systems have been programmed using Python[4]-[5].

B. Ultrasonic Sensor

The ultrasonic sensor module used in this project is HCSR04. The ultrasonic sensor transmits a wave and the received echoes are decoded to sense the presence of physical objects. The specifications of HC-SR04 are:
1. 2cm 400cm (1 to 13 feet)
2. Working Voltage 5V
3. Working Current 15mA
4. Working Frequency 40KHz
5. Trigger input signal required 10s pulse (3V - 5 V HIGH)
6. Echo signal voltage 5V (has to be brought down to 3.3V to avoid damage to Raspberry Pi GPIOs)[6]

HC-SR04 has been connected to the Raspberry Pi as shown in Figure 1. A voltage divider circuit is used to bring down the voltage from 5V to 3.3V as Raspberry Pis General Figure 1 HC-SR04 connection to Raspberry Pi Purpose Input Output pins (GPIOs) cannot tolerate a voltage above 3.3V .

C. GPS Receiver

The GPS Receiver used in this project is Adafruit Ultimate GPS. It is a high quality GPS receiver module. It can track up to 22 satellites and has an excellent highsensitivity receiver.

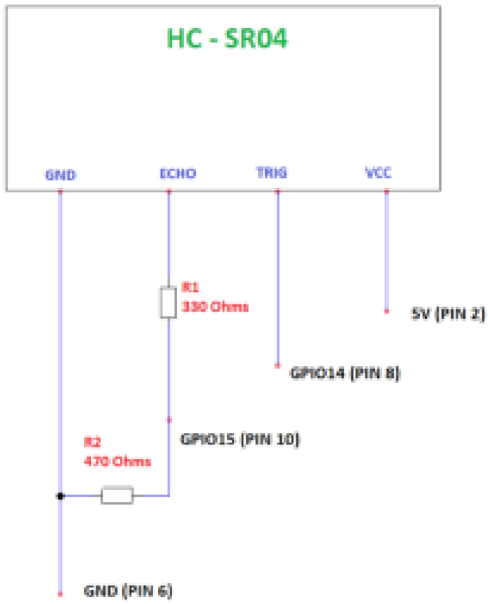


Fig. 1. HC-SR04 connection to Raspberry Pi.

It has very low power consumption and draws only 20mA. Other specifications are:

1. Patch Antenna Size: 15mm x 15mm x 4mm
2. Update rate: 1 to 10 Hz
3. Position Accuracy: 1.8 meters
4. Velocity Accuracy: 0.1 meters/s
5. Warm/cold start: 34 seconds

The GPS receivers pins are connected to the USB port of Raspberry Pi using a USB TTL serial cable.[7]

D. Audio Output

Both systems interact with the user through voice feedbacks. A light weight ear-piece will be connected to the 3.5mm jack of the Raspberry Pi, to be used by the user to get the voice-feedback.

E. Power Supply

A rechargeable power source will be used in this project. The source will power the Raspberry Pi through a micro USB and can be recharged using the widely available mobile phone charger.

III. METHODOLOGY

The main system flowchart is shown in Figure 2. It clearly depicts the two systems working parallelly and independently of each other.

As seen in the flowchart, the GPS navigation system begins with getting the data from the GPS receiver. The GPS receiver gets a variety of data from the satellites. The GPS module synchronises with a minimum of 4 satellites and

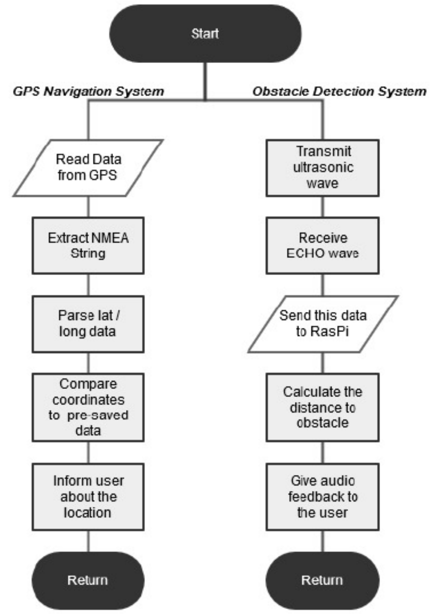


Fig. 2. System Flowchart.

on some occasions up to 10 satellites (on a clear day). The GPS module gives the NMEA string as the output. [8]The NMEA message is in the form of an ASCII message string consisting of geospatial location, time and other relevant information.The NMEA sentence types which the module used in this project recognize are GPGGA, GPGSA, GPRMC, GPVTG and GPGSV. For this project only GPGGA string is needed, hence, a program, written in python is used to extract the required data.[9] An example of the string:

GPGGA,124923,5206.041,N, 01640.001, E,1,06,0.9,523.7,M, 34.1,M,,*34
GGA Global Positioning System Fix Data
124923 Fix taken at 12:49:23 UTC
5206.041, N Latitude 52 deg 06.041' N
01640.001, E Longitude 16 deg 40.001' E
1 Fix quality
06 Number of satellites being tracked
0.9 Horizontal dilution of position
523.7, M Altitude, Meters, above mean sea level
34.1, M Height of geoid (mean sea level) above WGS84 ellipsoid
34 the checksum data, always begins with *[10]

After this, the latitude and longitude coordinates are extracted from the string. These coordinates are then used in the GPS Navigation system of the advanced guide cane. The coordinates are compared to some predefined coordinates of known locations. Whenever the coordinates encounter a match, the user is informed of being in the particular location via voice feedback.[11]
The obstacle detection system works on the principal of ultrasonic waves. The ultrasonic sensor transmits a wave and the received echoes are decoded to sense the presence of physical objects.[12] The ultrasonic sensor used in this

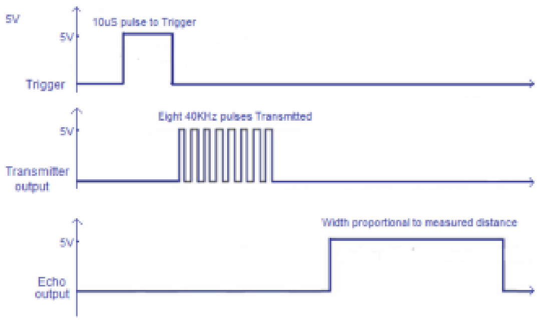


Fig. 3. Figure 3 Timing Diagram of HC-SR0.

project, HC-SR04, requires a 10s Trigger pulse to begin its operation. This pulse is sent to the TRIGGER pin of the sensor, by the Raspberry Pi. When the sensor encounters this pulse, it transmits eight 40 KHz pulses, and simultaneously starts a timer. When the sensor detects the echo pulses, it stops the timer, and sets the ECHO pin high using the time value obtained from the timer. ECHO pin is connected to Raspberry Pi, and using it the Raspberry PI gets to know the time taken by the ultrasonic waves to reach the obstacle and come back. Using equations (1) (2), the program running on Raspberry Pi, determines the distance to the obstacle.

$$34300 = Distance/(Time/2) \tag{1}$$

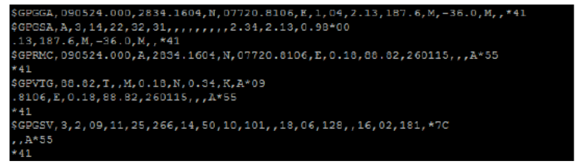
$$17150xTime = Distance \tag{2}$$

Thus, obstacles are detected without actually touching them. The cane has various threshold levels for distance with different sound emitted for different distance from the obstacle. This project uses 10, 50 and 90 cm, as the levels for distance measurement. The module has been programmed using Python programming language and operates on an infinite loop, which make the module to be able to function continuously.[13]
The audio system for both the GPS Navigation system and Obstacle Detection system has been made using Pygame module, a programming module to create games and animations. Various channels have been created to accommodate various voice feedback commands and sounds so as to get uninterfered sound playback.

IV. TESTING AND RESULTS

Both systems were tested individually at first. The functionality of the HC-SR04 was tested in the beginning. It was found out that the minimum distance that the sensor is able to measure is 5cm. The maximum distance the sensor was able to measure was 200 cm. 200 cm is well beyond the range we need for our advanced guide cane.
The GPS receiver gave correct NMEA string results as shown in Figure 4. The accuracy of the GPS receiver was tested using online map services as shown in Figure 5.

The GPS Navigation system in the project is being tested for E-Block, Amity University, Uttar Pradesh. The system has to correctly identify the 4 gates of the E-Block and inform the user accordingly. The coordinates of the gates are shown in Table 1. During system testing each location was correctly identified during each run.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$GPGGA,090524.000,2834.1604,N,07720.8106,E,1,04,2.13,187.6,M,-36.0,M,,*41
$GPGSA,A,3,14,22,32,31,,,,,,,,,2.34,2.13,0.98*00
.13,187.6,M,-36.0,M,,*41
$GPRMC,090524.000,A,2834.1604,N,07720.8106,E,0.18,88.82,260115,,,A*55
*41
$GPVTG,88.82,T,,M,0.18,N,0.34,K,A*09
.8106,E,0.18,88.82,260115,,,A*55
*41
$GPGSV,3,2,09,11,25,266,14,50,10,101,,18,06,128,,16,02,181,*7C
,,A*55
*41
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Fig. 4. NMEA Strings.

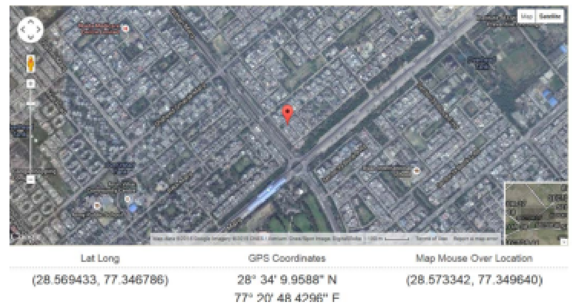

Fig. 5. GPS Accuracy Test Result.

The obstacle detection system was tested independently and it could detect distance from as small as 4 cm to 200 cm, as shown in Figure 6. The system also played correct sound in each distance range.

To run these systems simultaneously, the two different python scripts were run on Raspberry Pi. The scripts ran without interference and worked as expected.

V. CONCLUSION

This paper provides an overview of an advanced version of the walking stick used by people, specially made for the visually impaired. The GPS Navigation system described can be easily modified to be used at any location like home, office or university. The obstacle detection system can be used at any location to aid the user in navigating easily. In future GPS can be combined with GIS (Geographic Information System) that may help blind person to know the surroundings better. The data received from both can guide the visually using audio feedback like Move 7 steps straight and then take a right turn and move 3 steps.

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TABLE I. LIST OF COORDINATES FOR THE GATES OF E-BLOCK

Location	Longitude Range	Latitude Range
E1 Gate	77.334550 to 77.334750	28.545180 to 28.545390
E2 Front Gate	77.333610 to 77.333850	28.544710 to 28.544950
E2 Rear Gate	77.334050 to 77.334220	28.544310 to 28.544550
E3 Gate	77.333010 to 77.333250	28.543850 to 28.544200

REFERENCES

[1] WHO Media Centre (2014 August) Visual Impairment and Blindness [Online] Available: http:// www.who.int/ mediacentre/factsheets /fs282/en/

[2] R. Velzquez, Wearable Assistive Devices for the Blind Wearable and Autonomous Biomedical Devices and Systems for Smart Environment Lecture Notes in Electrical Engineering Volume 75, 2010, pp 331-349

[3] S. Brassai, L. Bako, and L. Losonczi, Assistive Technologies for Visually Impaired People, Acta Universitatis Sapientiae Electrical and Mechanical Engineering, Vloume 3, 2011, pp 39-50

[4] Adafruit Learning Centre (2015, March 14) Introducing the Raspberry Pi Model B+[Online] Available: https://learn.adafruit.com/downloads/pdf/introducing-theraspberry-pi-model-b-plus-plus-differences-vs-model-b.pdf

[5] Elec Freaks Ultrasonic Ranging Module HC - SR04 [Online] Available: http://www.micropik.com/PDF/HCSR04.pdf

[6] Kewin Townsend (2015 May 4) Adafruit Ultimate GPS on the Raspberry Pi[Online] Available: https://learn.adafruit.com/adafruit-ultimate-gps-on-theraspberry- pi/introduction

[7] A Amjed S. Al-Fahoum, Heba B. Al-Hmoud, and Ausaila A. Al-Fraihat, A Smart Infrared Microcontroller- Based Blind Guidance System, Active and Passive Electronic Components, vol. 2013, Article ID 726480, 7 pages, 2013. doi:10.1155/2013/726480

[8] M. Bousbia-Salah and M. Fezari, The development of a pedestrian navigation aid for the blind, GCC Conference, 2006.

[9] T. H. Win and Z. M. Aung, Vehicle Navigation System using GPS Receiver, International Conference on Advances in Electrical and Electronics Engineering (ICAEE'2011) pp. 161164.

[10] S. N. Parmar, Designing and Implementing Navigation and Positioning System for Location Based Emergency Services, Technology Systems and Management Communications in Computer and Information Science Volume 145, 2011, pp 248-253

[11] Mahdi Safaa A., Muhsin Asaad H. and Al-Mosawi Ali I, Using Ultrasonic Sensor for Blind and Deaf persons Combines Voice Alert and Vibration Properties, Research Journal of Recent Sciences 2012, vol. 1, no. 11, pp. 5052.

[12] S. S. Bhatlawande, J. Mukhopadhyay, and M. Mahadevappa, Ultrasonic spectacles and waist-belt for visually impaired and blind person, 2012 National Conference on Communications(NCC 2012), pp. 811.

[13] Ameer H Morad," GPS Talking for Blind People", Journal of Emerging Technologies in Web Intelligence, Vol. 2, No. 3, August 2010, pp 239-243.