IoT Based Self-Navigation Assistance for Visually Impaired

Nilesh Dubey, Gaurang Patel, Amit Nayak, and Amit Ganatra

Abstract One of the major challenges faced by visually challenged people is self-navigation in unknown environments. They often tend to get hurt by objects that they cannot feel using their hands or a walking cane, as certain objects are hard for a blind person to detect by just using tapping their walking cane. To avoid obstacles and navigate through a new environment, a smart belt for the visually impaired is performed in which he/she can continuously detect the obstacles around the user with its sensors that span the entire 360° of his/her field of view. Whenever an obstacle is in a nearby range, sufficiently enough to cause a hindrance, the device will give sensory cues to the user about the location of the obstacle and family members are also tracked them using GSM and GPRM system.

Keywords GSM · Obstacle detection · Visually impaired · HC-05 sensor system

N. Dubey (✉) · G. Patel
Department of Computer Science and Engineering, Devang Patel Institute of Advance Technology and Research, Faculty of Technology and Engineering (FTE), Charotar University of Science and Technology, Changa, India
e-mail: nileshdubey.ce@charusat.ac.in

G. Patel
e-mail: gaurangpatel.dcs@charusat.ac.in

A. Nayak
Department of Information Technology, Devang Patel Institute of Advance Technology and Research, Faculty of Technology and Engineering (FTE), Charotar University of Science and Technology, Changa, India
e-mail: amitnayak.it@charusat.ac.in

A. Ganatra
Department of Computer Engineering, Charotar University of Science and Technology, Changa, India

A. Pasumpon Pandian et al. (eds.), *Computer Networks, Big Data and IoT*, Lecture Notes on Data Engineering and Communications Technologies 66,
https://doi.org/10.1007/978-981-16-0965-7_48

1 Introduction

Unlike us, blind or visually challenged people are not blessed with the same gifts, and consequently, they cannot perform the same tasks with the same parity as what a normal individual could do. In an entirely novel place, they might be able to dodge the obstacles coming in their way with the help of the walking cane but knowing where to go seems like an uphill climb without any external help as they are unfamiliar with the layout. This could lead to getting lost sometimes, which would be a difficult situation to get out of. The current solution also renders them with only one usable hand while walking, which in some cases may be a minor inconvenience. Countless other problems are not mentioned here but affect them daily.

The project aims to mitigate the most common problems of their struggle and make their lives comparable to ours. It takes advantage of a simple wearable belt that everyone can adorn. On the belt, there would be ultrasonic SR-04 sensors fitted, about six of them which handle their own respective direction. Four sensors are entirely dedicated to the *X*-*Y* plane, i.e., the horizontal plane located at about the waist height of the wearer. They continuously pulse in the four major directions, i.e., North, East, West, and South. This way, the entire 360° field of view of the blind person is covered by the sensors. The extra two sensors cover the vertical plane, and they check for any obstacles on the floor which may come in the way of the person. Hindrances at the head height of the person should also be taken care of, which is done by the sensor aligned at the pre-decided angle with the horizontal plane. For the additional features, the distress alert feature helps them to stay connected wherever they are. In any event of trouble, this feature will notify all the people which were set earlier when setting up the device. Additionally, with the help of an Android app, connected to the device via Bluetooth, it can help in navigating walking distances by giving turn by turn directions to the user via the handset connected by the auxiliary port with the Android phone. Through this app, blind people walk safely outdoors or in traffic areas.

2 Existing Work

2.1 Smart Mobility Aid for the Visually Impaired Society

Electronics is a domain that is constantly growing and developing [1–4]. There are approximately 15 million people who are blind in India. Major developments square measure worn out a sensible for seeking a well and smarter life and welfare toward the blind society. This paper [4–6] recommends and pursues a thought of removing the stick and mounts these sensors on the visually handicapped individual body itself.

2.2 Real-time Dangling Objects Sensing

The initial style of mobile ancillary device for pictorial impaired [7–10] was discussed. This analysis planned a mobile real-time dangling objects sensing (RDOS) model that is mounted on a front of a cap for obstacle detection. This device uses relatively low-cost audible sensing parts which provide balance sense for blinds to know the anterior projected things. The RDOS gadget can the executives the sensor's front point that is at the client's body stature and upgrades the detecting precision. The RDOS gadget can manage the sensor's front angle that is at the user's body height and enhances the sensing exactness [11]. Two major required algorithms are to live the height-angle activity and un-hearable detector alignment and planned unit space. The analysis team to boot combined the RDOS device with mobile automation devices by act and Bluetooth to record the walking route.

2.3 Assistive Infrared Sensor-Based Smart Stick for Blind People

In this article, the authors proposed a lightweight smart stick that is relatively inexpensive, very user-friendly, and easy to use [12–14]. The smart stick gives a quick response to the user about the obstacles ahead and helps them with better mobility and uses low power consumption. The stick utilizes infrared technology; a cluster of infrared sensors can observe stair-cases and totally different obstacles presence at intervals the user path. As a stick could be an acquainted object to a blind man thus employing a good stick for higher quality and obtaining the device would be terribly straightforward [15, 16]. The experimental results provide smart accuracy and thus the stick is prepared to watch all of the obstacles [17].

3 System Components

3.1 Arduino Uno

The ATmega328 AVR microcontroller is the core of the Arduino Uno R3 microcontroller board. It consists of 20 digital input and output pins which comprise six PWM outputs and six analog inputs. A computer program named Arduino Uno IDE is used to load the code from the computer to the Arduino. The Arduino has widely used in the world which makes it an extremely simple approach to begin working with embedded electronics.

3.2 Ultrasonic Sensor SR-04

The ultrasonic sensor SR-04 is used to measure the distance between the sensor and some object. The way distance is measured by the sensor is that it emits a sound, usually about 40 kHz which falls in the inaudible range for humans, but the sensor is capable of picking it up. After emitting the sound, the sensor waits for the sound to bounce back from the object, and it measures the time taken. With the help of time taken, it gets conceivable to calculate the distance between the object and the sensor. The general formula speed is equal to distance divided by time is used here. It is rearranged to be distance which is equal to speed multiplied by time. The next step is to simply plug in the values for the speed of sound and the time measured by the sensors in the previous step and obtains the distance. Here, the distance calculated would be the round-trip time, which means the distance from the sensor to the object and the distance between the object and the sensor. To solve this, just divide the distance by two.

$$\text{distance} = \frac{\text{speed of sound} * \text{time taken by sound}}{2} \tag{1}$$

3.3 Bluetooth Module

HC-05 module is an unbelievably essential Bluetooth SPP (Serial Port Protocol) module, proposed for direct far off successive affiliation plan. The HC-05 Bluetooth module can be used in a master or slave design, making it a viable answer for remote correspondence. This sequential port Bluetooth module is a totally qualified Bluetooth V2.0+EDR (enhanced data rate) 3Mbps modulation, and it contains an absolute 2.4 GHz radio handset and baseband. It uses CSR Blue center 04-External single-chip Bluetooth structure with CMOS development and with adaptive frequency hopping feature (AFH). Bluetooth, a ton of explicitly Bluetooth low energy (BLE), has become the overwhelming innovation for associating Internet of Things (IoT). The innovation is also ready to keep up the quality correspondence range all through the trade. This low energy form of Bluetooth may totally affect IoT innovation, by giving gadgets the adaptability to existing and with progress perform during a huge decision of use situations. Bluetooth empowers low force correspondence between gadgets that are in the closed closeness of each other existing instrument.

4 System Design

This is the basic format of how the sensors are placed around the belt and what field of views will they cover. The lines *a* and *b* work on the XY plane, toward the front

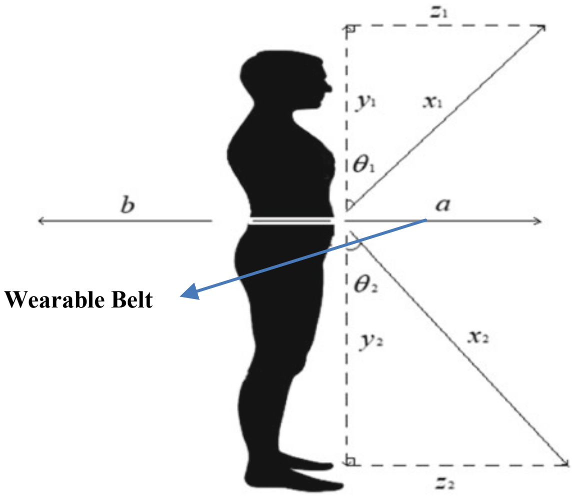

Fig. 1 Representation of the proposed system with wearable belt

and rear of the wearer, respectively. Both sensors are not person dependent, and they will have the same configuration regardless of the wearer because they work in a straight line perpendicular to the user. The height of the wearer will not affect their function in any way (Fig. 1).

The next two sensors sit at a little distance from the sensor with the line of sight *a*. The problem with fitting all the sensors equidistant to one another is that two sensors will fall on either side of the torso which is the normal resting position for both the arms. Hence, putting them on the sides will give erroneous results as hands constantly interfere with the reading of the sensors. The remaining two sensors have a slightly tricky implementation. Their implementation depends on the height of the wearer as well as the waist height of the wearer concerning the ground. The sensors are placed at an angle over and below the front sensor. The bottom sensor, with the line of sight x_2 detects the steps or little obstacles along the way of the user. The problem with placing the sensor pointing straight down is that due to the walking it is impossible to detect the distance accurately. Also, it is pointless to do that as the detection of the obstacles takes longer time. Hence, the angle θ_2 is placed concerning the vertical plane. The distance x_2 will depend on the height y_2 at which the user wears the belt on his waist as the Pythagoras theorem will be applied here.

$$x_1^2 = y_1^2 + z_1^2 \quad (2)$$

Also, to calculate without the distance, the formula is very useful.

$$\cos\theta_1 = \frac{y_1}{x_1} \quad (3)$$

The sensor which detects above the head of the user works in a very similar way with a slight difference. The distance x_1 is decided on y_1, but y_1 is not the height

Table 1 Values are taken for the respective variable and generated values of θ

Parameters	x_1	y_1	z_1	θ_1	x_2	y_2	z_2	θ_2
Data	128.6	91	91	45°	142.8	101	101	45°

of the wearer; it represents a distance that is slightly above the height of the wearer from the waist. This is done because objects near the head of the user can pose a significant threat while walking. The code is designed in such a way that it will trigger the buzzer if anything is detected closer than 20 cm to the height of the head of the user.

With the current tested data, the following table is prepared using the device (Table 1).

4.1 Design Requirements

(1) It has one input because of having one degree of freedom.
(2) It is a coplanar mechanism with at least four links.
(3) It has at least one combine pair to form a non-uniform output speed.
(4) It has at least one gear pair to vary the uniform resultant speed.
(5) It has a ground link to support or constrain other links.
(6) It has one output link.

4.2 Design Constraints

(1) The number of links should be four or five links.
(2) The frame must be a link with three joints or more to have a firm support.
(3) At least one cam pair must be incident to the frame.
(4) The input link must be adjacent to the frame with a revolute joint.
(5) The input link, the output link, and also the frame should be appointed on completely different links.

5 Experimental Results

After rigorous testing, it can be concluded that six sensors are the optimal solution required for this device to work efficiently. It creates a good balance between the working and affordability of the device, and it provides enough sensory cues for the visually impaired person. Anymore several sensors will confuse the user and exacerbate the problem instead of alleviating it. To implement the sensors in many different combinations of wearables, environments found that a belt can be used in

Table 2 Classification of hurdle based on sensor readings

Type of hurdle	Type of alert
Non-uniform path	Voice alert Beep 1
Small object	Voice alert Beep 2
Large object	Voice alert Beep 3

all kinds of weather and can be worn by almost everyone. Also using the HC-05 sensor instead of the SIM9000 sensor proves to be a wise choice as the recipient of the SIM9000 sensor can be poor at times which prevents the distress feature from working. With the connection of an Android phone via a Bluetooth sensor to the device, accurate latitude and longitude can be sent with precision (Table 2).

6 Conclusion

The project work aims to solve an underlying problem that has been overlooked for years. The technology for the masses has seen an exponential growth, while it has been stagnant for a certain demographic. This device will replace a tried and tested practice used by blind people, i.e., walking and navigating with the help of canes. The benefits that this product will provide to the users are subtle yet revolutionary. The simple convenience of having both hands-free while still being able to walk freely in a known or unknown location should be available to everyone. This device helps in making blind people more independent with the use of SOS features and more familiar with technology in general. Thus, the obstacles were detected using the SR-04 sensors via measuring their latency of the 40 kHz sound signal and processing using the algorithm used by the Arduino Uno.

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