Abstract—The visually challenged commonly experience difficulty in walking on Indian roads due to the presence of many manholes. They also find it difficult to recognize staircase in the indoor environment. This smart stick is developed using ultrasonic sensors, Arduino kit and python for detection of manholes, staircases and water levels (during rainy season). Arduino programming is used for the recognition of manholes and water level. This is implemented in a light weight stick using Arduino Uno board and ultrasonic sensors. The real time staircase detection is achieved with the help of python language. Adding to these features, the stick which falls from the hands of the blind person can be easily found using RFID reader and RFID tag. This feature enables the visually challenged to detect the exact location where the stick lies and hence, they can independently pick up the stick. Therefore, this project would enable the visually challenged to become more independent while walking on outdoor and indoor environment.

Keywords—Arduino, Ultrasonic sensor, Bluetooth, Python, Staircase detection

INTRODUCTION

According to the latest report, over 1.5 million people are visually impaired in India and face difficulties in conducting their day-to-day activities. This population is approximately 170 million worldwide and this figure is rising by 10 percent annually according to the latest statistics.

This project aims at helping the blind people to travel independently. Major problems faced by blind people are presence of manholes and walking on the roads during rainy. They also find it difficult to recognize staircase in the indoor environment. They also experience difficulty in detecting the walking stick if it slips from their hands. To overcome these problems many steps have been taken to help the blind people by implementing sensors in the stick used by them and give a alert to them through a buzzer.

HARDWARE

The hardware setup consists of Arduino Uno, ultrasonic sensor HC-SR04, Bluetooth module HC-05, RFID reader and RFID tag and buzzers.

A. MANHOLE DETECTION

The ultrasonic sensor is mounted to the stick 's bottom and the sensor faces the ground. The sensor emits ultrasonic waves which is reflected back to a receiver when an obstacle is encountered. The distance is calculated by using the formula, Distance = \((\text{Speed} \times \text{Time}) / 2\). A maximum value is set and compared with the measured distance. Whenever a vacuum (Manhole) is identified, distance calculated will be a larger value. Threshold value is calculated by taking a set of ten values considering the stick positions at various angles in front of the manhole. The cycle is repeated and the threshold of the maximum mean value is set. The flow chart for manhole detection is shown in Figure.1
The manhole detection requires 2 important components. They are

1. ARDUINO UNO

Arduino boards are constructed using a variety of sand controllers from microprocessors. Such boards are mounted in a series of pins mainly used for digital input and analog (I/O) output. A serial connection is called as the programming codes are loaded onto another device.

The picture of Arduino UNO is given below in Figure 2.
2. HC SR04 ULTRASONIC SENSOR
They are primarily used to catch the signals more easily, the ground-level signals are transformed to a time domain using the transformation function. Ultrasonic sensors are mostly considered for identifying the distance.

![HC SR04 Ultrasonic Sensor](image)

Figure 3. HC-SR04 Ultrasonic sensor

Ultrasound Sensor shown in Figure 3 has 4 connectors, namely Vcc (5V), Trig, Echo, and GND. Trig (trigger) aims at detecting a high-level ultrasonic pulse for at least 10 microseconds and then the returning pulse is automatically detected by the Echo plate. This provides the ability to evaluate distances by using the formula to determine the echo between the sending times to the return time

\[
Distance \ D = \frac{\text{Wave time to return} \times \text{Sound speed}}{2} \div 2.
\]

Table 2 gives the pin connectivity of Arduino pins.

<table>
<thead>
<tr>
<th>Arduino Pins</th>
<th>Connected Device Pin</th>
</tr>
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<tbody>
<tr>
<td>D2</td>
<td>Buzzer</td>
</tr>
<tr>
<td>D9</td>
<td>Trigger pin of HC-SR04</td>
</tr>
<tr>
<td>D10</td>
<td>Echo pin of HC-SR04</td>
</tr>
<tr>
<td>5V</td>
<td>Common +5V to all devices</td>
</tr>
<tr>
<td>GND</td>
<td>Common Ground (-) to all devices</td>
</tr>
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B. STICK DETECTION USING RFID READER AND RFID TAG
When the stick falls from the hand of the visually challenged, it can be detected easily with the help of RFID reader and RFID Tag. The RFID Reader is placed near the smart stick handle while the blind person has the RFID Tag in his pocket. If the stick slips from the hand, the person can scan the ground with the help of the RFID tag present with them. If the stick is detected, then the Reader on the stick produces a sound indicating the location where the stick has fallen. Therefore, the blind person can easily pick up the stick from that location.

1. RFID READER
A RFID reader (Radio Frequency Identification Reader) is a device which is used to collect information from an RFID tag to track individual objects. Radio waves are used to relay tag data to a reader. RFID Block Diagram is shown in Figure.4

![RFID-Reader Block diagram](image)
A: RFID READER EM-18 MODULE
An affordable solution for RFID based application is the EM-18 RFID Reader module running at 125 kHz which is shown in Figure 5. The Reader module comes with an antenna on chip and can be operated with a 5V power supply. Power up the module and attach the module's transmit pin to get your microcontroller pin.

![EM-18 Reader Module](image1)

**Figure 5. EM-18 READER MODULE**

2. RFID TAG
The RFID tag shown in Figure 6 is a device which can be attached to or integrated into a product, animal, or individual for the purpose of radio wave identification and tracking. Figure 7 shows the block diagram of RFID Tag.

![RFID Tag](image2)

**Figure 6. RFID TAG**

![RFID Tag Block Diagram](image3)

**Figure 7 Block diagram of RFID TAG**

C. WATER LEVEL DETECTION
The ultrasonic sensor transmits an ultrasonic pulse, and the distance to the target is determined by measuring the time needed for the return of the echo. A fixed value is fixed as the threshold. The calculated distance is compared with the threshold. If the calculated distance exceeds the threshold, then an alert is given stating that water on the road is above the safety level. Else, the next distance is measured and compared with the threshold.
1. THRESHOLD VALUE CALCULATION
Length of the stick = 123cm
Fixed safety level of water = 50cm
Threshold = (123 – 50) cm = 73cm

Therefore, the threshold value is fixed as 73cm. Alert should be given when the distance between the handle of the stick and water level becomes less than 73cm.

2. COMPONENTS USED
Apart from Arduino UNO and HC-SR04, the water level detection requires a HC05 Bluetooth module. Guarantee of precise functioning is obtained with the help of HC-05 Bluetooth module.

A. HC05 BLUETOOTH MODULE
In order to carry out the wireless serial connection Bluetooth HC-05 module as shown in Figure 8 is considered in this work.

![Figure 8. HC05 Bluetooth Module](image)

3. PIN CONFIGURATION
The HC-05 Bluetooth module has 6 pins, Pin connectivity is shown in Table 3.

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</tr>
<tr>
<td>TX</td>
<td>RX of Bluetooth HC05</td>
</tr>
<tr>
<td>RX</td>
<td>TX of Bluetooth HC05</td>
</tr>
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a: ENABLE
Once the enable is pulled LOW the contact channel fails. When enabler remains open or connected to 3.3V, connectivity will be established and communicated with other processors as long as this module remains in the HIGH position. The different commands are interpreted using the second pin, Vcc indicating voltage...
supply and the ground pin indicating GND. This also uses two other pins intended for communication with the UART interface, namely TXD and RXD.

b: STATE
It serves as a significant needle from which the signal phase can be understood. The signal status is shown to be low when connected to another Bluetooth device. At this point, the signal status specifies HIGH and at the same time it indicates that the pairing has not been established whenever an LED light flashes. The signal goes Low when the module is not connected to another Bluetooth device or paired with any other Bluetooth device.

c: BUTTON SWITCH
To create a connection between the Bluetooth for data transfer, it is important to set the switch module in the Bluetooth system in activate mode, which is possible with AT commands.

4. SOFTWARE

The Software requirements include Arduino Open source IDE, Anaconda navigator (Python) and Cascade Trainer GUI.

A. ARDUINO 1.8.8
The open-source Arduino Software (IDE) facilitates the writing and upload of code to the board. It runs on Windows, Linux and Mac OS X. The framework is written in Java and is based on Processing and another program that is open source. This software can be used with any Arduino board using this program.

B. ANACONDA NAVIGATOR (PYTHON)
Python is a language of programming that is interpreted, of high level, of general use. Python features a program of dynamic style and automated memory management. This supports various programming paradigms, including object-oriented, imperative, functional, and procedural paradigms, and has an comprehensive standard library too.

Anaconda Navigator is a graphical desktop user interface included in Anaconda that allows you to launch applications and manage conda packages, environments and channels easily without the need for command line commands.

C. CASCADE TRAINER GUI:
Cascade Trainer GUI is a software that can be used to practice, evaluate and refine models for classifying cascades. It uses a graphical interface to set the parameters and make it easy to use Open CV tools for the classification training and testing. Here this program is used to train a set of positive and negative images and to construct an XML file that is given to the python code as input.

5. EXPERIMENTS AND RESULTS

On interfacing the ultrasonic sensor with Arduino, the distance measured by the sensor can be viewed in the Serial monitor of the Arduino open source software. This is depicted in Figure 9.

Figure 9. Distance measurement depicted in serial monitor
The stick which was proposed and designed could be more beneficial for visually impaired people to safely navigate both indoors and outdoors.

Low cost, reliability, and portability are main features of the proposed program. Given the fact that the device is fitted with sensors and other parts, weighs about 600 grams of the PVC stick used for this function. It is found during the testing process that once the sensor detects a hollow signal, the sensor is triggered and produces an audio signal announcing that a manhole is in front of it. This is depicted in Figure 10.

![Smart stick equipped with sensors and alarms](image)

**Figure 10. Smart stick equipped with sensors and alarms**

The distance measured by the ultrasonic sensor can also be viewed on a smart phone using Bluetooth Electronics application. This is depicted in Figure 11 and Figure 12.

![Established connection to Bluetooth module](image)

**Figure 11. Established connection to Bluetooth module**

![Distance measured](image)

**Figure 12. Distance measured**
For staircase detection based our training set consists of 19 positive samples of staircases and 18 negative training samples. These samples are trained using Cascade trainer GUI software and the result is depicted in Figure13.

![Figure13. Result XML file obtained after cascading](image)

The cascaded file is given as input to the python code and staircase is detected from the trained files. The detected staircase is shown in Figure 14.

![Figure 14 Output of staircase detection](image)

6. CONCLUSION AND FUTURE WORK

This main objective of the proposed work is to create a smart stick that would assist the visually challenged in indoor and outdoor navigation. A novel work for the staircase detection for the visually challenged is discussed. Here an image-based method to determine the presence of staircase in the indoor environment using python was proposed. An RFID concept is used to allow easy identification of the position of the stick which falls from the blind person's hand. As an extension to the current research and with the advent of high processing speed mobile processors, the phase recognition technique using image processing can also be completely implemented.
REFERENCES