# ULTRASONIC SENSOR BASED SMART BLIND STICK FOR VISUALLY IMPAIRED INDIVIDUALS

**Bachelor of Technology**
**Electronics and Communication Engineering**


Submitted By

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# 1. ABSTRACT

A white cane has long been used by people with sight impairments to help them navigate when they are outside. Blind people have found the white cane to be helpful in increasing their mobility, but regrettably, it has limitations.

The fact that the white cane could only identify objects that were within its contact ranges is one of its drawbacks. Due to a lack of time to recognize and alert them to new obstacles in their path, this issue might occasionally put the blind person in danger.
This study suggests a walking stick system that can identify a front hole and determine whether a barrier is low or high in height. The visually impaired will be able to avoid or step over obstacles more easily if they can sense their height. The visually impaired should be able to avoid holes in time if they can identify them. The walking stick will utilize a laser sensor to detect holes and two ultrasonic sensors to determine the height of obstacles. The data from the sensors will be tracked and analyzed by a controller, and the user will receive feedback via a buzzer and vibration sensor.

The algorithm to differentiate the height of obstacles is working well and it is able to differentiate high or low obstacles. The laser ranging sensor has successfully been tested for hole detection. Therefore, the walking stick with ultrasonic and laser sensors will help more visually impaired to move around much faster and feeling more safer due to improved warning system for their movement.

## 2. INTRODUCTION

Visually impaired individuals often face challenges in brain information processing due to the absence of visual input, which leads to difficulties in maintaining orientation. As a result, they struggle to navigate in their desired direction. For indoor navigation, they cannot rely on smart systems using GPS because of signal limitations. Similarly, outdoor navigation becomes challenging in environments with low-height obstacles and holes. Studies suggest that visually impaired individuals can benefit from smart sensory devices; however, many such devices lack features like hole detection.

An innovative and efficient smart gadget equipped with various sensors can significantly assist visually impaired individuals by providing essential feedback. Innovation should continuously aim to improve the quality of life for these individuals. Many rely on smart canes as their primary tool for navigation, both indoors and outdoors. These devices work by allowing users to detect obstacles through physical touch, enabling them to recognize nearby objects. However, such tools do not help in identifying obstacles or hazards at a distance, which is crucial for safety and convenience, especially within a household environment.

In recent years, smartphones have been utilized for navigation by leveraging their inertial sensors and GPS capabilities. Despite some progress, the error rate in indoor navigation remains high due to sensor drift. As an alternative, Wi-Fi can be employed to create sensor networks for better signal direction detection. However, there remains a lack of smart canes with hole detection capabilities to support the visually impaired.

This work presents the design, application development, results, and future enhancements of a smart blind stick. The prototype incorporates various sensing technologies, such as ultrasonic and laser sensors, along with LEDs and a vibration motor, to create a comprehensive tool for visually impaired individuals. These sensors detect surrounding objects and enable users to perceive their environment effectively.

# 3. MATERIALS AND METHODS

## 1. Design of Smart Blind Stick

Figure 1 illustrates the architecture of the proposed smart blind stick designed for visually impaired individuals. The system's core component is a microcontroller, which connects to three input devices: two ultrasonic sensors and a laser sensor. Additionally, the microcontroller interfaces with output components such as an LED, a buzzer, and a vibration motor.

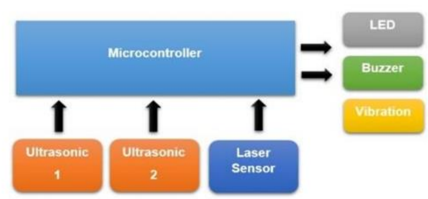


Figure 1. Block diagram of the proposed blind stick

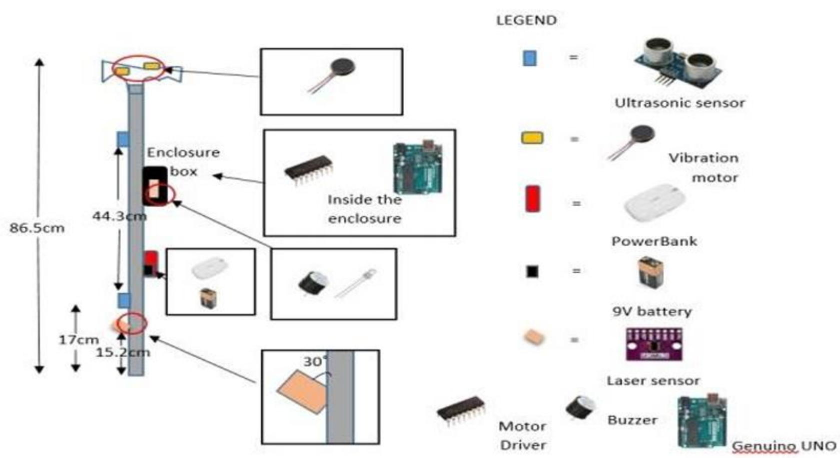


Figure 2. Layout of the smart blind stick

Figure 2 presents the design layout of the walking stick prototype. The components are mounted on a PVC pipe that measures 86.5 cm in length, chosen to provide optimal usability for blind users. The microcontroller (Arduino Uno) and the motor driver (L293D) are housed in an enclosure box positioned at the midpoint of the stick. The microcontroller runs the program, while the motor driver controls the vibration motor. The buzzer and LED are also placed near the enclosure box, with the LED indicating detected obstacles and the buzzer alerting the user when an obstacle is within 20 cm.

The stick is equipped with two ultrasonic sensors. The lower sensor, placed 17 cm from the base, detects low obstacles, while the upper sensor, positioned 44.3 cm above the lower one, detects high obstacles. The sensor placements were determined based on experimental results, ensuring effective coverage and detection for different obstacle heights.

The laser ranging sensor is mounted below the low obstacle ultrasonic sensor, 15.2 cm from the base of the stick. Its placement minimizes signal interference and optimizes hole detection. The sensor is tilted downward at a 30-degree angle to enhance its ability to detect holes in front of the user.

Two vibration motors are integrated into the stick's handle and covered with fabric for comfort. These motors alert the user by vibrating upon detecting an obstacle. The microcontroller and motor driver work together to ensure timely alerts.

Finally, the stick is powered by a power bank and a 9V battery. The power bank supplies energy to the microcontroller, while the 9V battery powers the motor driver, ensuring uninterrupted operation of the system.

## 2. Working Flow of the System

The working flow of the proposed system demonstrates the steps of avoidance higher obstacle and front hole as shown in figure 3. The upper ultrasonic sensor U1 recognize the obstacle from 100cm far, then the alarm will off; then the LED1 and vibration motor will turn on. If U1 detect an obstacle, it refers the deterrents are ordered as high obstacle in front. Other than that, if bottom U2 sensor detects an obstacle with a distance of 100cm, the signal will off; LED2 and vibration will turn on. If U2 identify an obstacle, it implies the low obstacle. However, in these steps if the obstacle within 20cm from the user, and then the LED2, ringer and vibration will turn on.

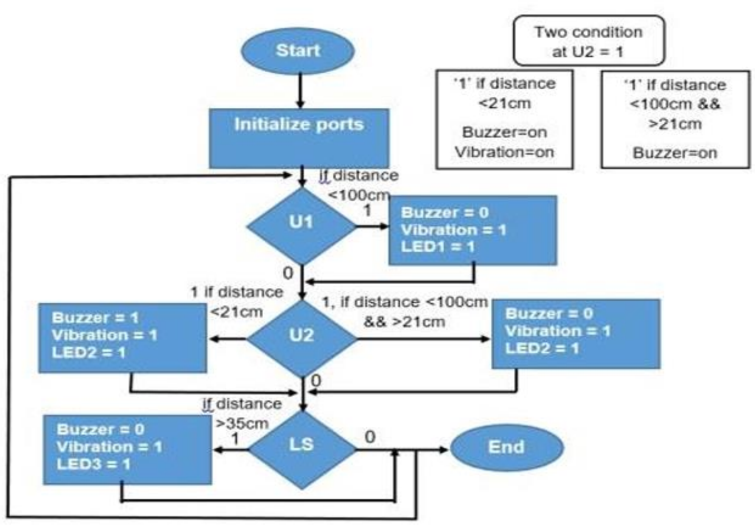


Figure 3. Working flow of the proposed smart walking system for visual impairment

## 4. RESULTS AND DISCUSSION

### Simulation of the Smart Walking Stick

Figure 4 illustrates the schematic diagram of the proposed blind stick system, which incorporates a microcontroller connected to two HC-SR04 ultrasonic sensors, LEDs, a vibration motor, and a buzzer. Due to the unavailability of the VL53L0X sensor in the Proteus software, laser sensor functionality was not used.

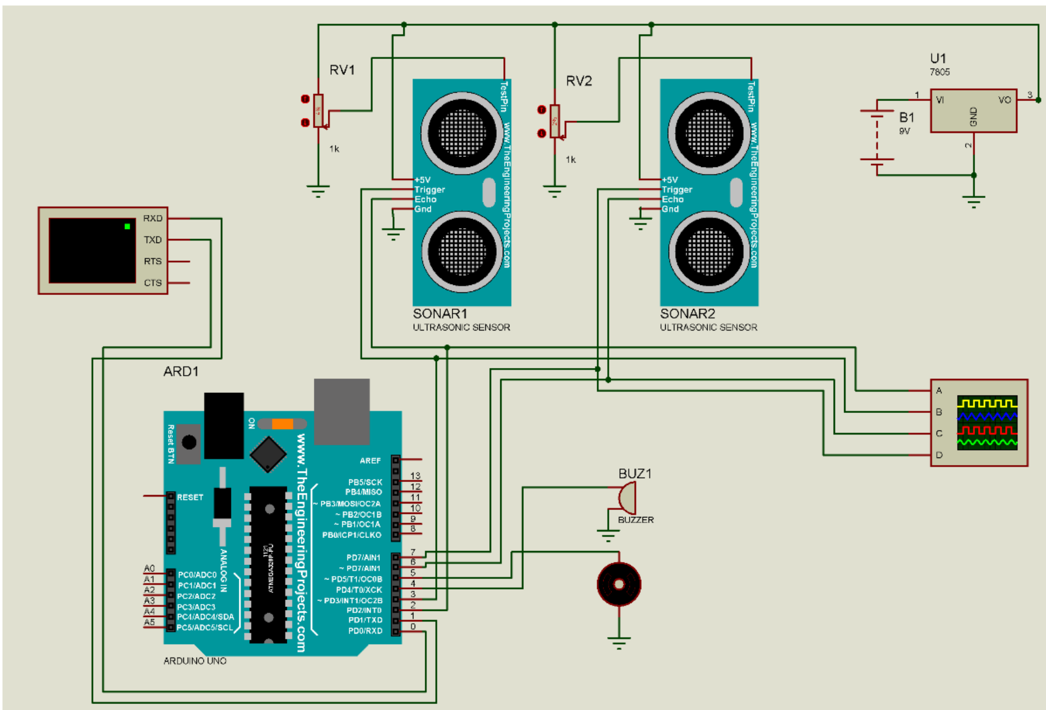


Figure 4. Schematic Diagram with Simulation test.

Figure 4 demonstrates the simulation test for observing the results of each sensor. Before simulating the schematic design, additional components such as a variable resistor, virtual terminal, and oscilloscope were included. The variable resistor enables voltage variation to change the distance values displayed on the virtual terminal, while the virtual terminal shows the distance values based on the variable resistor adjustments. The variable resistor connects to the test pin of each ultrasonic sensor, and the virtual terminal connects to the microcontroller's receiver and transmitter pins. The oscilloscope, connected to each ultrasonic sensor's echo pin, displays different pulse responses based on detected distances.

In the simulation process, sonar 1 was designated as the high obstacle sensor, and sonar 2 was designated as the low obstacle sensor. The virtual terminal displayed the distances detected by the 1st sensor (sonar 1) and the 2nd sensor (sonar 2). Motor 1 and motor 2 provided alerts when obstacles were detected. For high obstacles, only motor 1 vibrated. For low obstacles, motor 1 vibrated first, followed by motor 2.

***Arduino code:***

```
// Smart Stick for Visually Impaired //

const int trigPin1 = 3; // Bottom sensor trigger pin
const int echoPin1 = 2; // Bottom sensor echo pin
const int trigPin2 = 7; // Top sensor trigger pin
const int echoPin2 = 6; // Top sensor echo pin
const int buzzer = 4;   // Buzzer pin
const int motorPin = 5; // Vibration motor pin

long duration1, duration2;
int distance1, distance2;
const int safetyDistance = 30; // Safety distance threshold in cm
const int minDelay = 250;       // Minimum delay in ms
const int maxDelay = 1000;     // Maximum delay in ms

void setup() {
  Serial.begin(9600);
  pinMode(trigPin1, OUTPUT);
  pinMode(echoPin1, INPUT);
  pinMode(trigPin2, OUTPUT);
  pinMode(echoPin2, INPUT);
  pinMode(buzzer, OUTPUT);
  pinMode(motorPin, OUTPUT);
}

void loop() {
  // Measure distance from the bottom sensor
  digitalWrite(trigPin1, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin1, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin1, LOW);
  duration1 = pulseIn(echoPin1, HIGH);
  distance1 = (duration1 * 0.034) / 2;

  // Measure distance from the top sensor
  digitalWrite(trigPin2, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin2, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin2, LOW);
  duration2 = pulseIn(echoPin2, HIGH);
  distance2 = (duration2 * 0.034) / 2;
```

```
  // Calculate delay based on proximity (closer distance -> shorter delay)
  int delayBottom = map(distance1, 0, safetyDistance, minDelay, maxDelay);
  int delayTop = map(distance2, 0, safetyDistance, minDelay, maxDelay);

  // Object detected by the bottom sensor
  if (distance1 <= safetyDistance) {
    Serial.println("Object detected at bottom.");
    Serial.print("Bottom distance: ");
    Serial.println(distance1);
    digitalWrite(motorPin, HIGH);
    digitalWrite(buzzer, HIGH);
    delay(delayBottom); // Dynamic delay based on bottom distance
    digitalWrite(motorPin, LOW);
    digitalWrite(buzzer, LOW);
    delay(delayBottom);
  }

  // Object detected by the top sensor
  else if (distance2 <= safetyDistance) {
    Serial.println("Object detected at height.");
    Serial.print("Top distance: ");
    Serial.println(distance2);
    digitalWrite(motorPin, HIGH);
    digitalWrite(buzzer, HIGH);
    delay(delayTop); // Dynamic delay based on top distance
    digitalWrite(motorPin, LOW);
    digitalWrite(buzzer, LOW);
    delay(delayTop);
  }

  // No object detected
  else {
    Serial.println("No object detected.");
    digitalWrite(buzzer, LOW);
    digitalWrite(motorPin, LOW);
    delay(250);
  }
}
```

**Observations:**

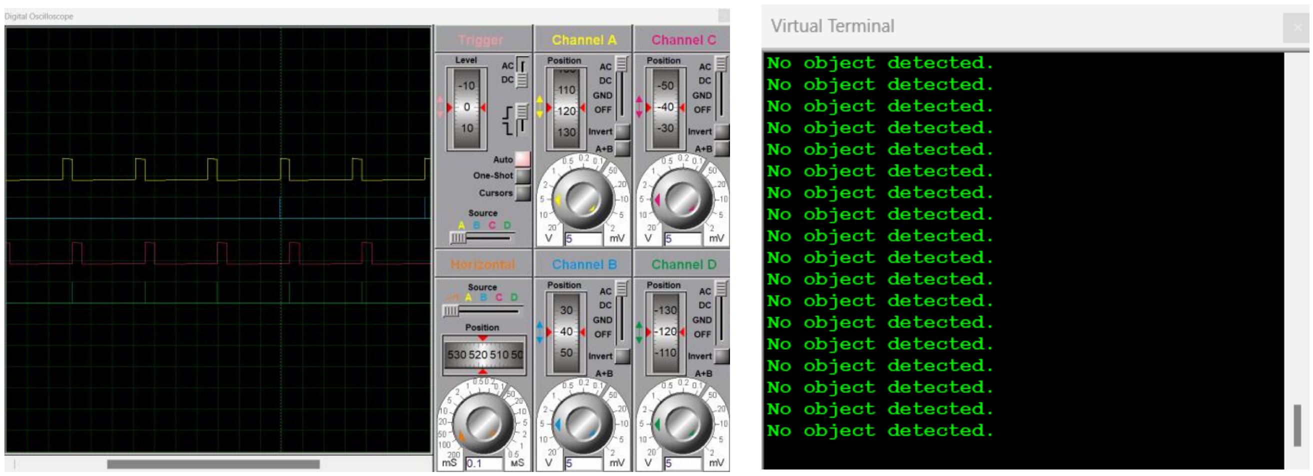

Figure 5. When both the sensor is off (object at far distance)

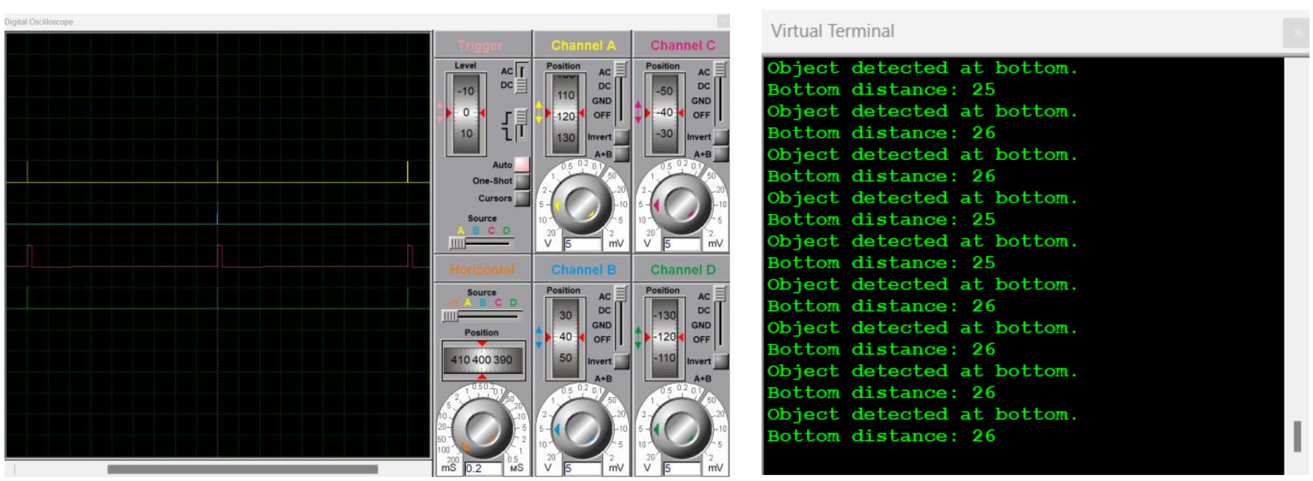


Figure 6. When bottom sensor is on, object found by bottom sensor at a distance of 25cm

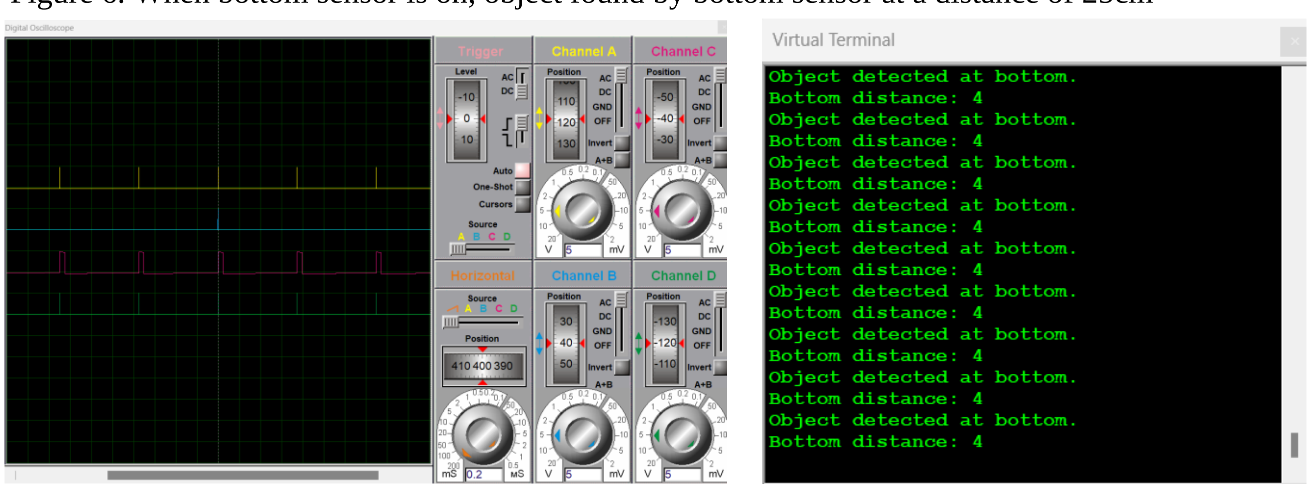

Figure 7. When bottom sensor is on, object found by bottom sensor at a distance of 4cm

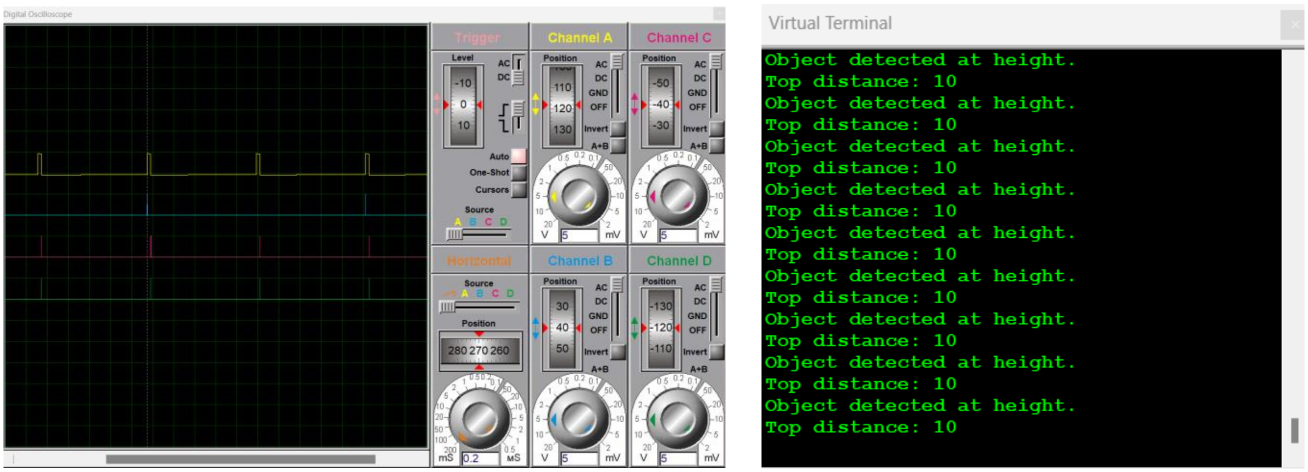


Figure 8. When upper sensor is on, object found by upper sensor at a distance of 10 cm

## 5. CONCLUSION

The smart blind stick prototype has been successfully designed and analyzed. The newly designed stick complies with the human ergonomics because it is developed for adult users. The blind stick prototype is tested for different heights of obstacles. In this work, two ultrasonic sensors are used to detect a different height of obstacles whether it is high or low. The smart blind stick is able to detect the obstacles with the height below 40cm, is considered low obstacle, on the other hand, if the detection height is more than 40cm, it is considered high obstacles. Therefore, this novel blind stick is capable to assist a blind person to move independently.