ELECTRONIC PRODUCT ENGINEERING WORKSHOP

(ECP 307)

Supervised By-

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Electronics & Communication Engineering

PROJECT WORK

PROJECT NAME: SMART THIRD-EYE CANE FOR THE VISUALLY IMPAIRED

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PROJECT REPORT

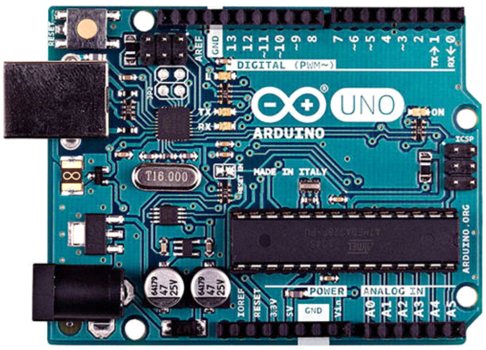
Abstract:

The visually impaired face a multitude of difficulties in everyday life. They are forced to rely on others to navigate the environment around them, and to warn them of hazards that may or may not be present. This significantly hinders their independence. Normally, this handicap is alleviated somewhat by use of a blind man's cane, a white stick that is used to obtain tactile information about the immediate environment by gently tapping on various objects. However, this cane has a fixed range of about 1.5m. This project aims to extend the effective range of this cane to approximately 4.5m, and to provide additional information about the immediate environment without the need to physically make contact with every surface. The system consists of multiple ultrasonic sensors and both auditory and haptic feedback from the cane.

Components used:

- **Arduino Uno:**

  The Arduino Uno is a microcontroller board based on the ATmega328 microprocessor. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs), a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. It can be programmed using the Arduino IDE.

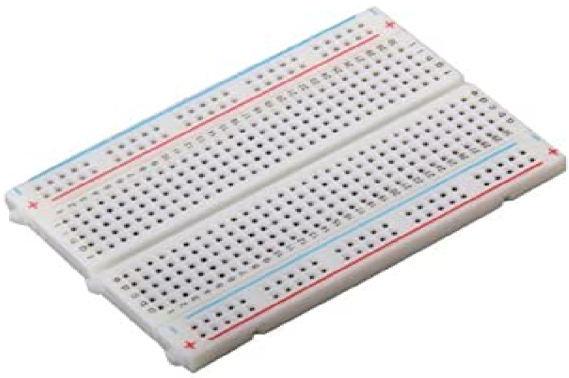


- **HCSR-04 Ultrasonic Sensor**: (3 units)

An ultrasonic sensor is a device that fires a pulse of sound at a frequency above the human hearing range when triggered, then measures the time it takes for the signal to return after reflection. They consist of two components - the transmitter, which uses a piezoelectric crystal to generate the sound and receiver, which captures the sound to generate a signal. Here, it is used to measure distance.

- **<u>Breadboard:</u>**

  A breadboard is a rectangular plastic board with several tiny holes in a grid pattern. These holes may have wires or component leads inserted into them, allowing for rapid non-permanent prototyping of electronic circuits and subsequent testing. Breadboards can be then converted into permanent circuits by soldering the components in place.



- **<u>Buzzer:</u>**

  A buzzer/beeper is an audio signalling device. They typically produce a buzzing noise, that can be adjusted in terms of pitch, frequency, waveform etc. through user or programmer input.

- **<u>Vibration Motor:</u>**

  A vibrator is a coreless DC motor that is very compact. The main purpose is not to drive an axle or induce rotation, but to rapidly vibrate itself and the components attached to it in order to generate haptic feedback to an electric signal.

- **9-volt battery (rechargeable).**
- **DC Male Power Jack.**
- **Jumper Cables.**
- **Toggle Switch.**
- **3/4' diameter PVC pipe of appropriate length.**
- **3/4' PVC pipe-elbow.**
- **Screws for mounting the Arduino.**
- **Insulating tape.**
- **Box large enough to contain Arduino, batteries etc.**

<u>Software Tools used:</u>

- **<u>Arduino IDE 1.8.13:</u>**

  The open source Arduino IDE is used to write and upload code to the Arduino board through a USB cable. The environment is written in Java and the language is based on C. It is compatible with all Arduino boards.

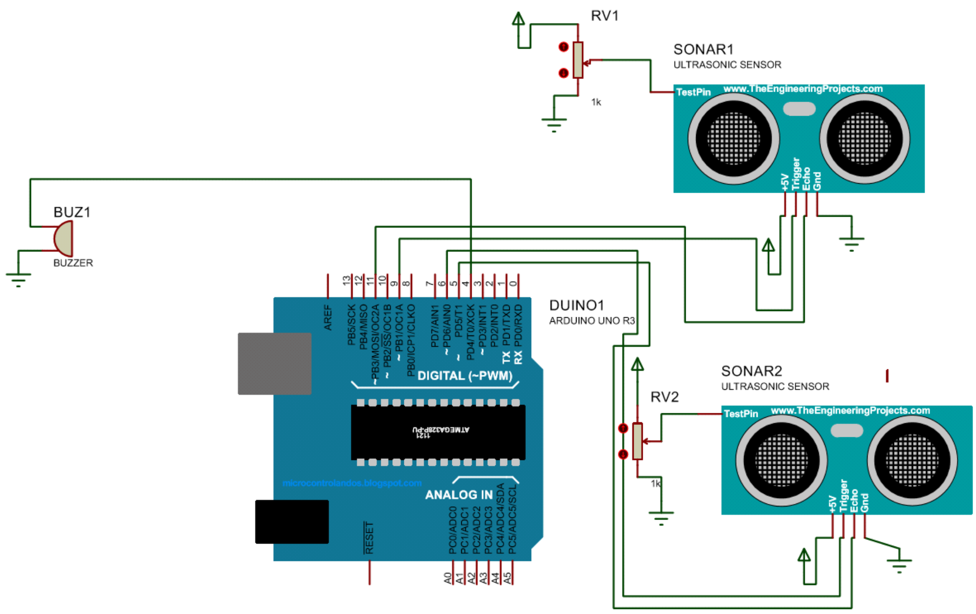
- **LabVIEW:**

  LabVIEW (Laboratory Virtual Instrument Engineering Workbench) is a system-engineering software that allows for the testing and measurement of hardware components in response to simulated environments in real-time. Here, it is used to simulate the devices and their response to the environment prior to their hardware implementation.

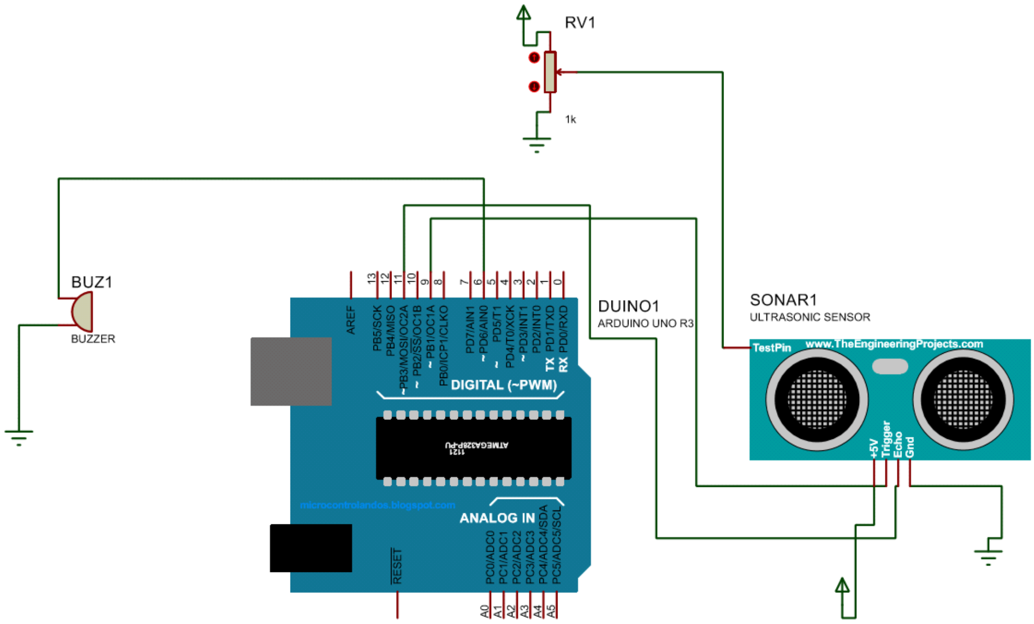
- **Proteus Design Suite:**

  The Proteus Design Suite is used to design PCBs and rapidly prototype circuits.

Circuit Diagram:



(for two sensors)



(for one sensor)

Working of the Project:

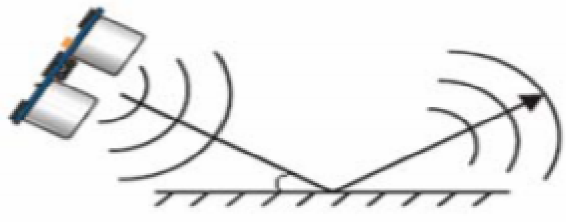
The ultrasonic sensors are mounted at strategic points on the cane, two at the handle and one at the tip. The handle-mounted sensors are oriented in order to cover both horizontal and vertical directions, with a range of 30 degrees for both. The tip-mounted sensor points directly towards the ground, though not in direct contact with it. All the aforementioned sensors are connected to an Arduino and a power supply (9V battery) which is contained in the box, attached to the stick at a convenient location. Additionally, a toggle switch is mounted on the box, which activates/deactivates the whole system.

At this point, the working is as follows:

1. At regular intervals, the Arduino sends a trigger signal to all the sensors.
2. Due to this trigger, the sensors fire eight bursts of ultrasonic sound, and initiate a time counter. Upon receiving the echo of the signal, the timer stops and its value is sent back to the Arduino.
3. Sound travels at an approximately constant speed in regular environments. This speed is known. Therefore, using a TRD (time/rate/distance) formula, the distance of the object that caused the echo can be determined.

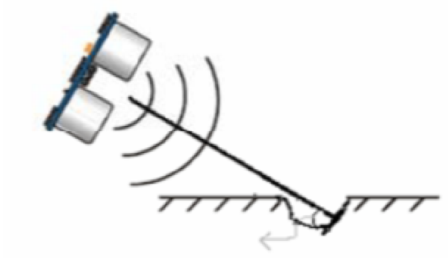
$$distance = \frac{time\ taken\ x\ speed\ of\ sound}{2}$$

4. Based on the distance calculated for each sensor, a corresponding feedback device will be adjusted. For example, consider the horizontal handle-mounted sensor. As it senses objects that are closer to it, the pitch of the buzzer will be increased. If an object moves away, the pitch is correspondingly decreased.
5. For Hump/Pothole detection, we used the concept of critical angle:
    a. Our bottom sensor is titled at a suitable angle for sending and receiving reflected rays. For normal ground with no irregularities, the ultrasonic burst from the Trigger will hit the ground and reflect away, and in normal circumstances, it will not return back to the Echo. As a convention, we can set a threshold as 15cm.



(a) plain ground

    b. For pothole, due to the ray hitting farther than the normal plain ground, it will reach the Echo late as the distance is a bit more, so we set our Pothole distance threshold in a range of 20-30cms for suitable results.



(b) pothole

Fig.6: *Ultrasonic burst hitting ground at (a) critical angle θ_c (b) $\theta > \theta c$*

    c. For hump, due to the ray hitting a closer than the normal plain ground, so it will reach the Echo sooner as the distance is reduced, so we set our Hump distance threshold as below 10cm for suitable results.
6. The feedback devices are as follows -
    a. As objects come closer to the person, the buzzer increases in pitch. The inputs for this are the handle-mounted sensors.

b. As potholes and bumps are detected, the vibrating motor is engaged and the strength of the vibration is proportional to the depth of the hole or the elevation of the bump.

Strictly speaking, the sensor can sense objects that are up to 5m away. However, precision is decreased after 3m, which is why the handle-mounted sensors will be restricted to sensing objects which are in the range of 10cm to 3m.

The tip-mounted sensor will be scanning for a range of 10cm to 20cm. Any readings that are above or below this range indicate a hole/bump respectively. Additionally, a no-return, that is, negative response indicates a sharp change in the inclination of the ground.

Status of Work Done:

Prior to the quarantine, the project had the following features -

- Three working sensors that accurately measure distance in a 30º field of vision.
- A box containing the Arduino and the power supply.
- Feedback devices (LED lights, buzzer and vibration motor) that independently responded in a manner directly proportional to the distance measured by the sensors. The LED was capable of varying intensity and frequency of flashing, and the buzzer was capable of varying frequency, loudness and waveform, based on code. The vibration motor responded to hump/pothole detection.
- Working Arduino code that calculates distance based on the sensor input and transmits operating instructions to feedback devices that are connected to it.

The functionality that was yet to be added is as follows -

- Mounting of all the sensors to a stick.
- Permanent soldering of all components to a PCB after successful testing.

Arduino Code:

```
int led=3;
int buzz=4;
int trig1=10;
int echo1=11;
int trig2=6;
int echo2=5;
int trig3=12;
```

```
int echo3=13;
int motor=7;

int t1;
int d1;
int val;
int t2;
int d2;
int t3;
in d3;
int d;

void setup()
 {

  pinMode(trig1,OUTPUT);
  pinMode(echo1,INPUT);
  pinMode(led,OUTPUT);
  pinMode(buzz,OUTPUT);
  pinMode(trig2,OUTPUT);
  pinMode(echo2,INPUT);
  pinMode(trig3,OUTPUT);
  pinMode(echo3,INPUT);
  pinMode(motor,OUTPUT);

  Serial.begin(9600);
}

void loop()
{
  //for forward obstacle detection (2 sensors):

  digitalWrite(trig1,LOW);
  delayMicroseconds(2);
  digitalWrite(trig1,HIGH);
  delayMicroseconds(10);
  digitalWrite(trig1,LOW);

  t1=pulseIn(echo1,HIGH);
  d1=t1*(0.01715);                              //distance = (duration/2) / 29.1

  digitalWrite(trig2,LOW);
  delayMicroseconds(2);
  digitalWrite(trig2,HIGH);
  delayMicroseconds(10);
  digitalWrite(trig2,LOW);

  t2=pulseIn(echo2,HIGH);
  d2=t2*(0.01715);                              //distance = (duration/2) / 29.1
```

```
if (d1<d2)
   d=d1;
  else
   d=d2;

 if (d<0)
   analogWrite(led,0);                       //LED is LOW for distances<0
 else if(d<=20)
  {
   val=12.75*(20-d);
   analogWrite(led,val);                     //brightness of LED depends on the distance
   digitalWrite(buzz,HIGH);                  // buzzer is HIGH for closer distances
   delayMicroseconds(8);
  }
 else
  {
   val=0;
   analogWrite(led,val);                     //LED is low for distances>20
   digitalWrite(buzz,LOW);                   // buzzer is LOW for farther distances
   delayMicroseconds(8);
  }

//for pothole/bump detection (one bottom sensor) which detects only when the reflected ray
//from the ground reaches the Echo sensor.
//As the third sensor is kept tilted at an angle for detection of bump as well as pothole,
//we set two distance thresholds, d3<10 for hump and 20<d3<30 for potholes.

 digitalWrite(trig3,LOW);
 delayMicroseconds(2);
 digitalWrite(trig3,HIGH);
 delayMicroseconds(10);
 digitalWrite(trig3,LOW);

 t3=pulseIn(echo3,HIGH);
 d3=t3*(0.01715);


if(d3<=10)                                   //10cm is set as the threshold for hump detection
  {
   digitalWrite(motor,HIGH);                 // vibration motor is HIGH for nearby humps
   delayMicroseconds(8);
  }

 else if(d3<=30 && d3>=20)    //range of 20-30cms is set as the threshold (pothole detection)
  {
   digitalWrite(motor,HIGH);                 //vibration motor is HIGH for nearby potholes
   delayMicroseconds(8);
  }
```

```
else
{
 digitalWrite(motor,LOW);     //for large distances and for those rays which didn't reach the
                              //Echo sensor after reflection, vibration motor is LOW
 delayMicroseconds(8);
}

   Serial.print("Distance1: ");
   Serial.println(d1);
   Serial.print("Distance2: ");
   Serial.println(d2);
   Serial.print("Distance3: ");
   Serial.println(d3);

  }
```

Results:

A cheap (estimated cost of approximately 600 rupees) and intuitive 'Smart Third-Eye' cane with a range that is over double the standard range was designed and partially implemented. The cane is capable of enhancing the visually-impaired individual's independence, allowing them to navigate in clustered environments with no external assistance while also allowing them to picture the closest objects to them. Additionally, the problems normally posed by holes/bumps in the ground is alleviated to a great extent due to the use of a bottom-facing tilted sensor.

However, this project is not infallible. It faces issues in detecting soft, sound absorbent materials like thick sheets of dense wool or other cloths. Additionally, it may suffer interference from other ultrasonic sensors that are pointed at it. Extreme fluctuations in temperature (of over 15ºC) may also reduce the accuracy of distances measured.