PROJECT BAT-EYE

Developing an Economic System that can give a Blind Person Basic Spatial Awareness and Object Identification.

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ABSTRACT-

Project BATEYE fundamentally uses an ultrasonic sensor mounted on to a wearable pair of glasses that measures the distance to the nearest object and relays it to an Arduino board. The Arduino board then processes the measurements and then plays a tone (150-15000Hz) for the respective distance (2cm to 4m) till the data from the second ultrasonic pulse (distance) comes in, and then the same process gets repeated. This cycle is repeated almost every 5 milliseconds. The person hears sound that changes according to the distance to the nearest object. The head provides a 195-degree swivel angle and the ultrasonic sensor detects anything within a 15-degree angle. Using systematic, cognitive and computational approach of neuroscience, with the hypothesis that the usage of the occipital lobe of blind people goes into processing other sensory feedback., and using the brain as a computational unit, the machine relies on the brain processing the tone produced every 14 mS to its corresponding distance and producing a soundscape corresponding to the tones and the body navigating using the same. During experimentation, the test subject could detect obstacles as far away as 2 – 3m, with horizontal or vertical movements of the head the blindfolded test subject could understand the basic shape of objects without touching them, and the basic nature of the obstacles.

1. INTRODUCTION-

The WHO projects that 285 million people are estimated to be visually impaired worldwide: 39 million are blind and 246 have low vision. About 90% of the world's visually impaired belong to the low income group. Scientists are trying to make eyes for the people who are blind. Some have even tried cathode ray implants inside the brain, but these are extremely expensive, provide very little vision and these procedures are invasive.

But what if we use another unconventional sense for sight? Bats can do it, dolphins can, why can't we? Echolocating animals emit calls out to the environment and listen to the echoes of those calls that return from various objects near them. They use these echoes to locate and identify the objects and obstacles. Since, about 90% of the world's visually impaired live in low-income settings, they can't afford anything but a walking stick that can't detect objects outside a 0.5 metre range or anything above waist height unless they don't collide with it. Basic spatial awareness is extremely important for any person, and therefore this device tries to solve the same problem. When the brain is deprived of input from one sensory organ, it can change in such a way that it augments other senses, a phenomenon called cross-modal neuroplasticity.

2. *METHODS AND IMPROVEMENTS-*

Approximately 90% of visually impaired people live in developing countries according to WHO projections. Since they the low cost is a very essential criterion, it is a must to make the device as economical as possible.

The initial research started off with analysing echolocation. Echolocation is the same as active sonar, using sounds made by the animal itself. Ranging is done by measuring the time delay between the animal's own sound emission and any echoes that return from the environment. The relative intensity of sound received at each ear as well as the time delay between arrival at the two ears provide information about the horizontal angle (azimuth) from which the reflected sound waves arrive. Echolocation had also been mastered by various humans too, who use clicks to find their way around, strengthening my hypothesis that soundscape based navigation was possible.

The selection of the correct sensor for the correct measurement of distance was extremely important because it needed to be cost effective, have a wide beam, and at the same time be able to detect versatile objects. In terms of accuracy, the infrared sensor was an obvious choice, but since it could only detect objects that weren't black, it wasn't used. I used an ultrasonic sensor (HC SR-04), which has a wider beam and can be used on all rigid bodies.

Various positions were tested for the mounting of the sensor-

1.) When mounted on the chest it could just detect objects in front

2.) When mounted on the palm of the hand the direction the palm was pointing was proving too difficult to judge for the blindfolded test subject

3.) when mounted on the head, it gives the most swivel angle, hence was used.

The original idea was to have two units mounted on the other sides of the head to test the curvature of any object in front, however when conducting experiments, the pulses from both the sensors were interfering causing bogus values to be returned by the sensors. Hence the idea of having two sensors working seamlessly was abandoned.

3. RESULTS-

1.) Swivel angle covered by the system- 195°
2.) Values returned by the sensor- When graphed.

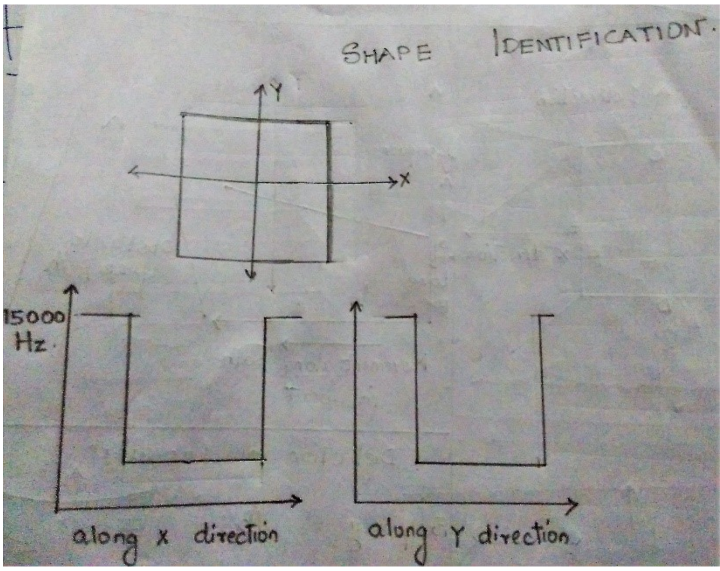

Figure 1. Test results for basic shape identification- Square

The test was performed by holding a big square cardboard.

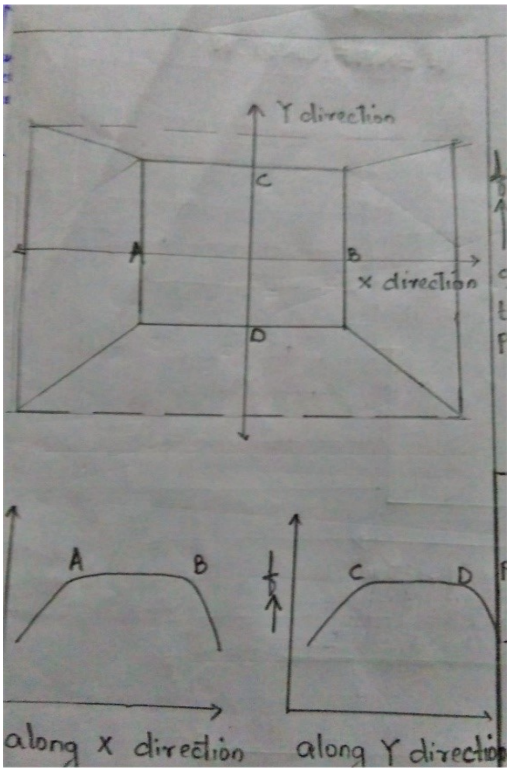

Figure 2. Mapping a normal cuboidal room

This test was carried out inside an empty cuboidal room to minimize interference from other objects. When the frequency of the tones produced are graphed with respect to head movement along a particular direction figure 2 is obtained.

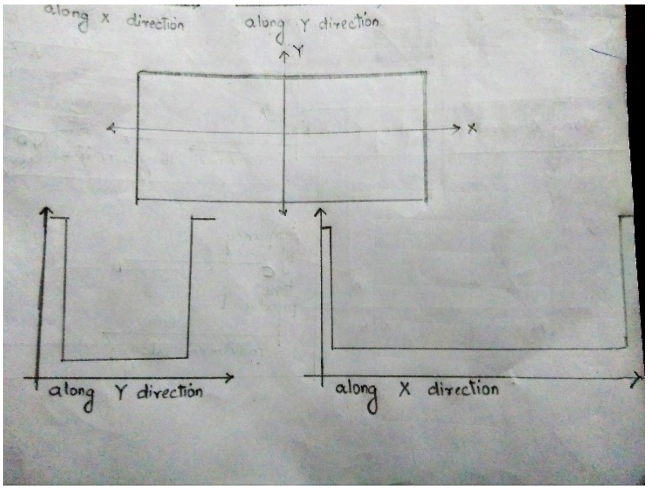

Figure 3. Basic shape identification (rectangle)

Test was performed by holding a big rectangular cardboard.

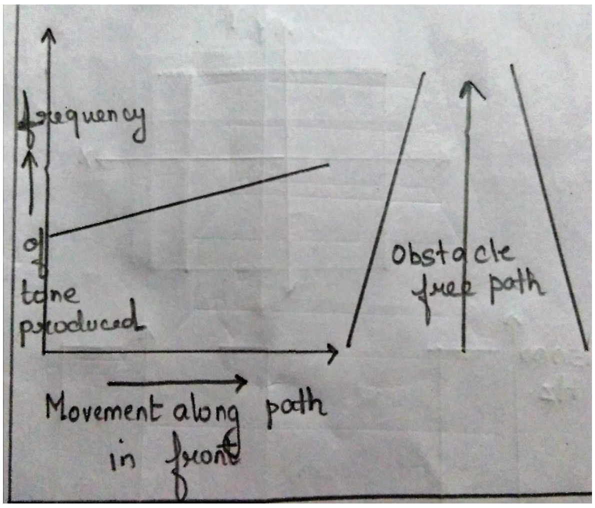

Figure 4. Soundscape produced for an obstacle free path in front of the person, when the device is moving in forward direction (or the direction in which the person wants to move).

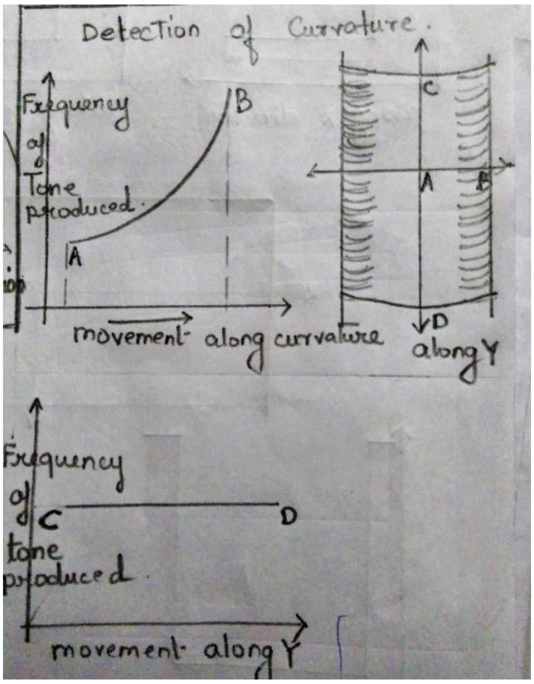

Figure 5. Soundscape produced when a pillar is mapped-(cylindrical) -When the frequency of the tones produced are graphed with respect to head movement along X or Y axes. This test was used to detect the system's ability to detect curvature.

Additional tests with obstacles- The blindfolded test subject was introduced to an environment with obstacles, a normal car parking area. He was able to detect obstacles as far as 3 metres (In an unknown environment). Initial disorientation was observed. Experimental testing exposed flaws with the system such as few inaccurate values returned by the sensor and problems with detecting soft objects and sometimes amounts of non-comprehendible noise. This was primarily produced by pointing the sensor towards objects that are rapidly shifting in position, or many objects kept at a faraway distance (caused by the beam angle). It also produced some unexpected results like being able to detect guide rods.

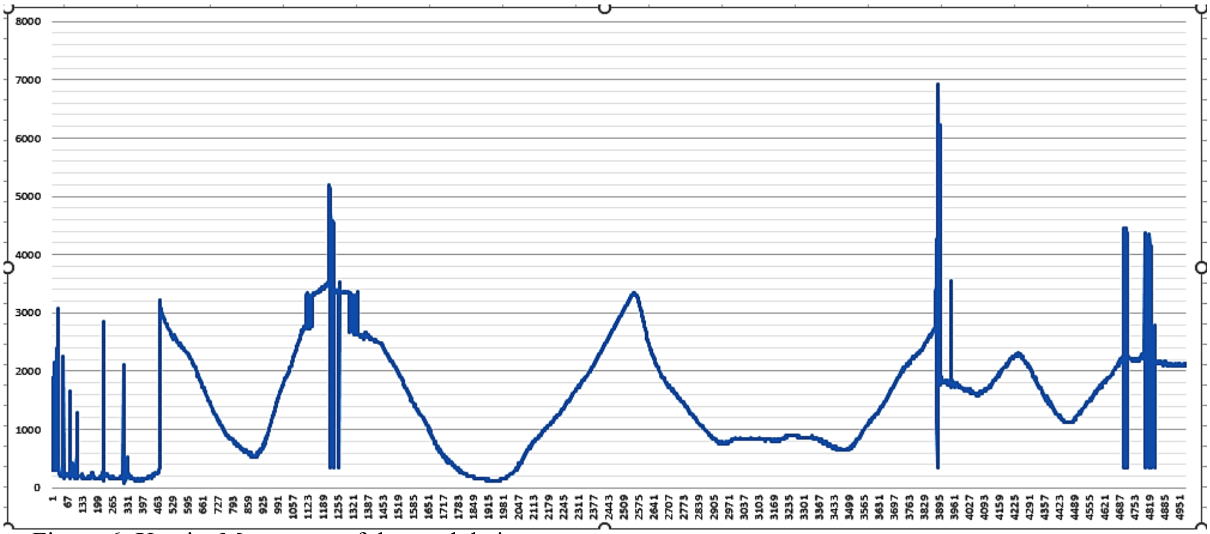

Figure 6. X axis- Movement of the module in whatever direction with time.Y axis – Frequency of the tone produced in Hertz
(Bateye module version 1 data)

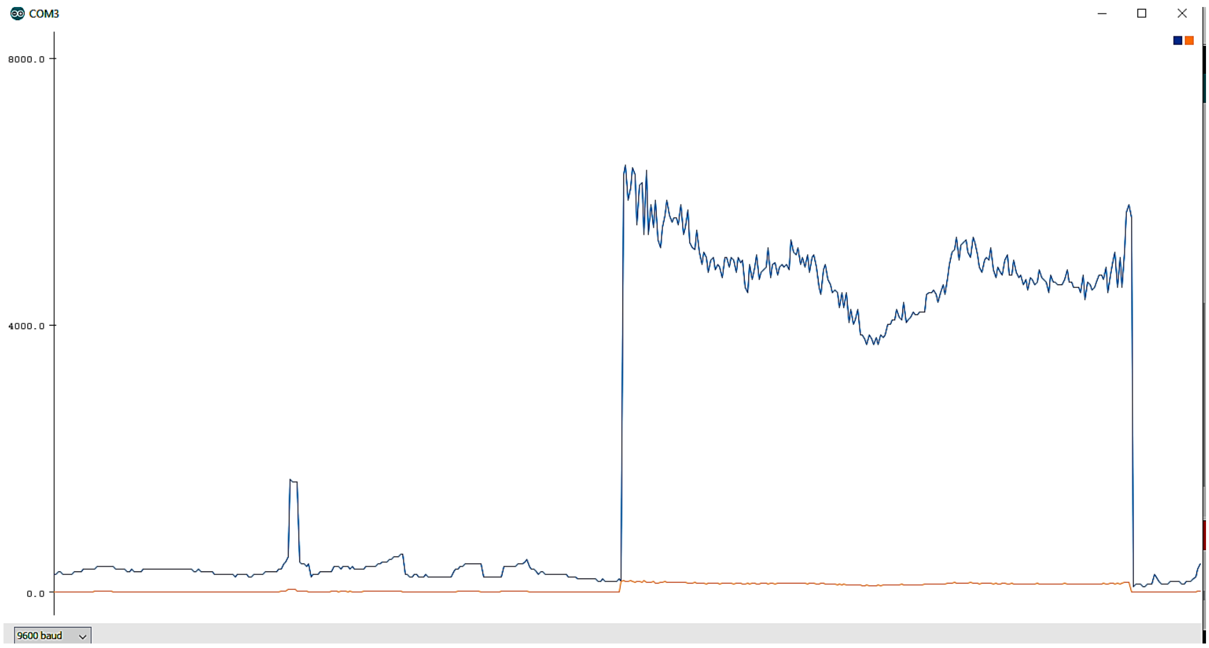

Figure 7. X axis- Movement of the module in whatever direction with time.Y axis – Distance (Blue) and Tone frequency produced (Orange)

(Bateye module version 2 data)

The above graph is an example of data feedback from the Bat-eye module – When Frequency is plotted against movement along various directions. This graph is from the values of frequency of tone sent from the Arduino board. *****_Due to the huge amount of data feedback, segregation of data into parts that describe each shape couldn't be done, therefore the first few graphs were plotted by hand._ ******

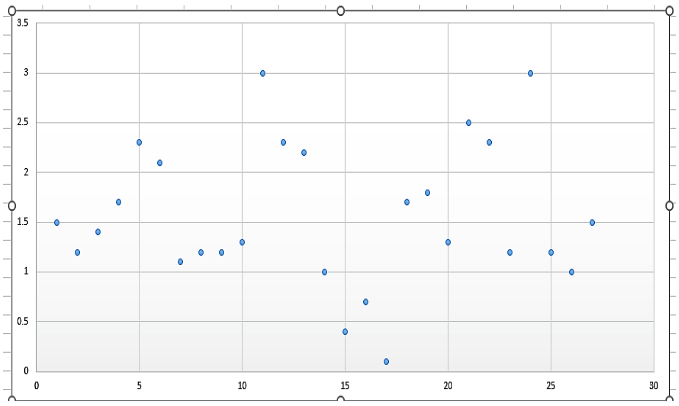

Figure 8. Scatterplot of distance at which obstacle or object was detected during test run.

Multiple tests were also run with cars in the car plot arranged in the shape of a maze , with a blindfolded subject with the bateye module being introduced into the unknown environment. Not only was the test subject able to escape the maze , but he was also able to come out without colliding with any of the walls (cars) which were at certain locations less than 0.5 metre away from each other.
This experiment definitely proves the ability of the Bateye module to provide the user with basic spatial awareness,

4. DISCUSSION and CONCLUSION-

The system could identify basic shapes, as well as give a person basic spatial awareness for navigation and obstacle avoidance at a low cost, as aimed, however, training for the blind people who are going to use the system (under controlled conditions) is necessary to understand what the tone feedback actually means to be able to use the device safely or to its fullest capabilities. Right now, It's imperative that further tests are carried out and extensive experimentation is done before the system is actually implemented as a substitute to the walking stick. It can be used as a supplement to the standard walking stick right now.

5. ALGORITHM-

{Repeat these steps every 5 milliseconds}
Step 1- Send pulse to Ultrasonic sensor
Step 2- Measure the time required for the sound wave to return
Step 3- Calculate the distance to the obstacle based on the time required for the wave to return, and the speed of sound
Step 4- Print the distance to the serial monitor
Step 5- Generate a frequency to correspond to the distance from the obstacle
Step 6- Play a tone on the speaker

```
const int trigPin = 3;
const int echoPin = 2;
void setup()
{
  // initialize serial communication:
  Serial.begin(9600);
}
void loop()
{
  // establish variables for duration of the ping,
  // and the distance result in inches and centimeters:
  long duration, inches, cm;

  // The sensor is triggered by a HIGH pulse of 10 or more microseconds.
  // Give a short LOW pulse beforehand to ensure a clean HIGH pulse:
  repeat:
  pinMode(trigPin, OUTPUT);
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);

  // Read the signal from the sensor: a HIGH pulse whose
  // duration is the time (in microseconds) from the sending
  // of the ping to the reception of its echo off of an object.
  pinMode(echoPin, INPUT);
  duration = pulseIn(echoPin, HIGH);

  // convert the time into a distance
  cm = microsecondsToCentimeters(duration);

  if( duration>10000)
  {
    goto repeat;
  }

  Serial.print(cm);
  Serial.print(" ");


  Serial.println();
  int OutputPin=9;
  unsigned int thisPitch = map(cm, 2, 400, 150, 15000);
   // play the pitch:
  tone(OutputPin, thisPitch, 10);      // delay in between reads for stability
  Serial.print(thisPitch);
  Serial.print(" ");
  delay(5);
}

long microsecondsToCentimeters(long microseconds)
{
  return microseconds / 29 / 2;
}
```

6. ACKNOWLEDGEMENTS

I would also like to thank my research mentor – Dr Krishnendu Chatterjee for his constant help throughout this research.

7. References

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