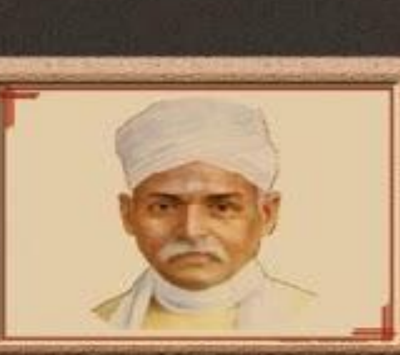


भारतीय प्रौद्योगिकी संस्थान
काशी हिन्दू विश्वविद्यालय

INDIAN INSTITUTE OF TECHNOLOGY
BANARAS HINDU UNIVERSITY

CELEBRATING CENTENARY
100 years
IIT (BHU) VARANASI

DESIGN AND INNOVATION HUB PROJECT

Echo-locating device for visually impaired person to detect shape, distance and motion of obstacle around (considering cost factor).

Kailash Ch. Bhakta, Alankrit Singh, Shiru Sharma

School of Biomedical Engineering,

Indian Institute of Technology (BHU) Varanasi

Correspondings: kchandra.bhakta.bme16@iitbhu.ac.in; alankrit.singh.bme16@iitbhu.ac.in; shiru.bme@iitbhu.ac.in.

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.

Abstract:

Project fundamentally uses an ultrasonic sensor mounted on to a wearable accessory 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 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 14mS 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.

Methods:

Approximately 90% of visually impaired people live in developing countries according to WHO projections. Since the 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,I used an ultrasonic sensor (HC SR-04), which has a wider beam and can be used on all rigid bodies.

The original idea was to have two units mounted on the shoulders 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.

ALGORITHM-

{Repeat these steps every 5 milliseconds}

Step 1-Send pulse to Ultrasonic sensor

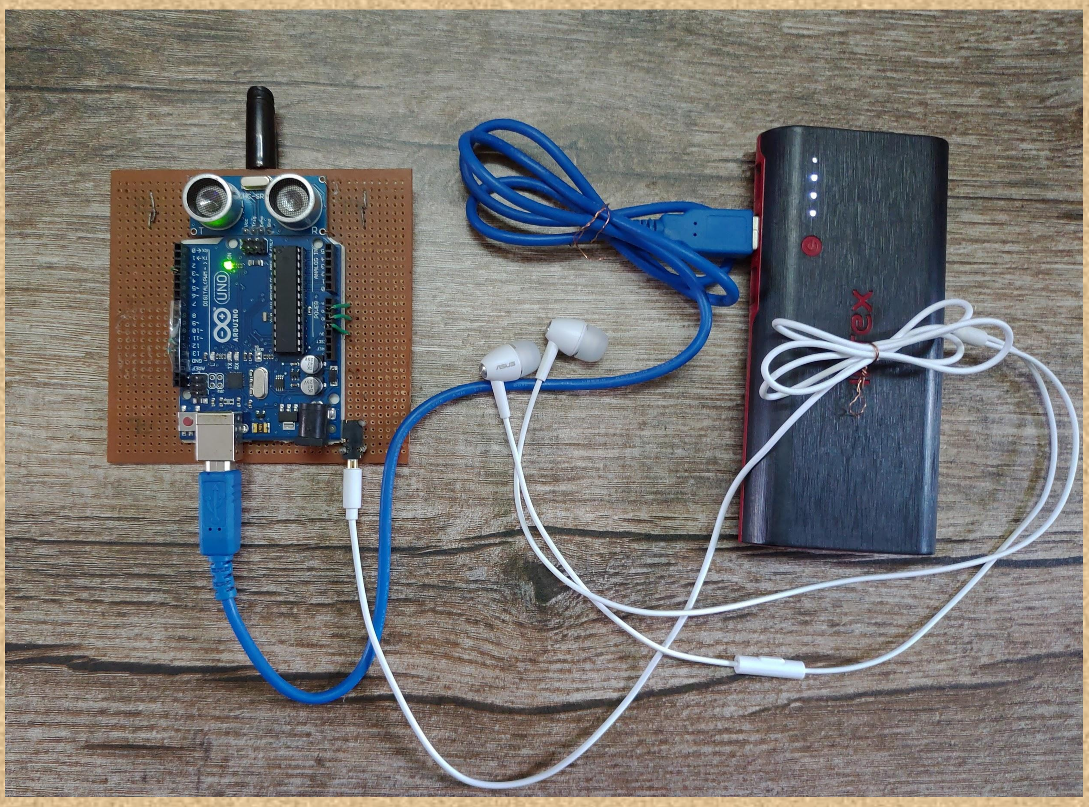
Step 2-Measure the time required for the sound wave to return

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 corresponding tone on the speaker



The test subject able to escape the maze ,& 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.

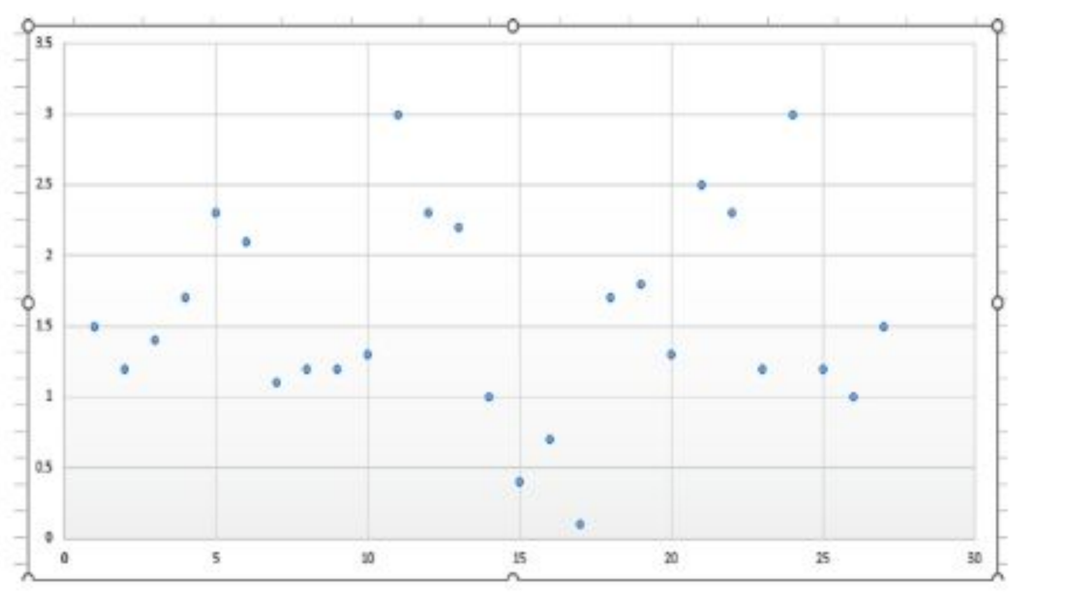


Figure 8. Scatterplot of distance at which obstacle or object was detected during test run.

Result & Discussion:

1.) Swivel angle covered by the system- 195°

2.) Values returned by the sensor- When graphed.

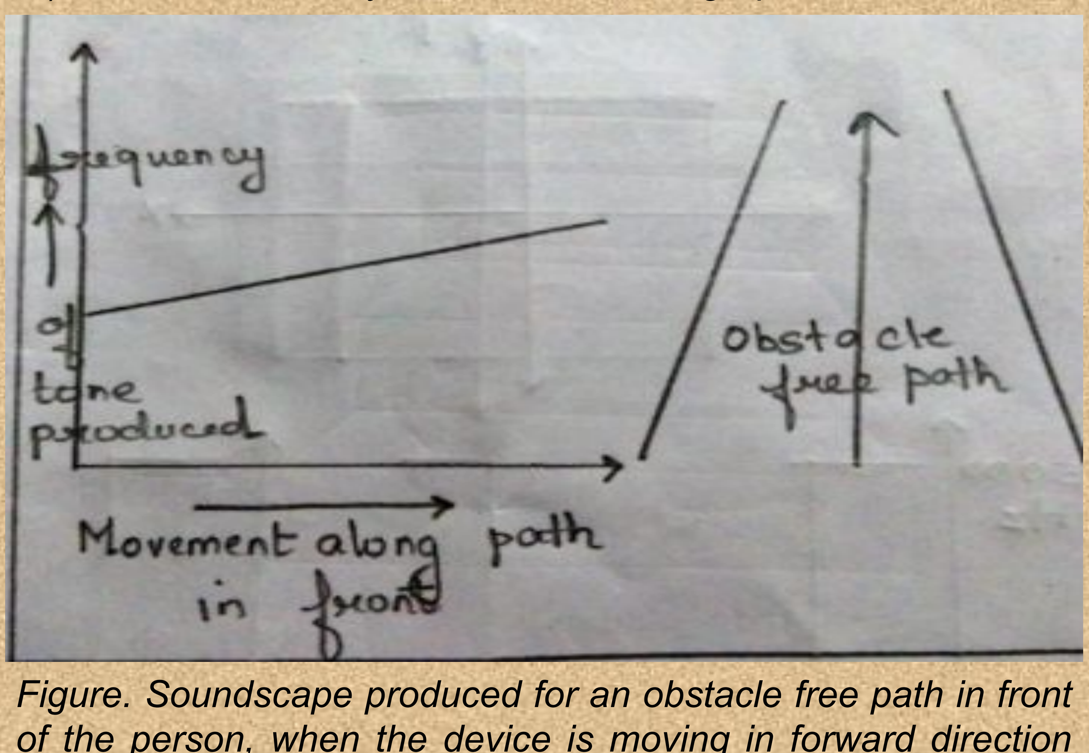


Figure. Soundscape produced for an obstacle free path in front of the person, when the device is moving in forward direction (or the direction in which the person wants to move).

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).

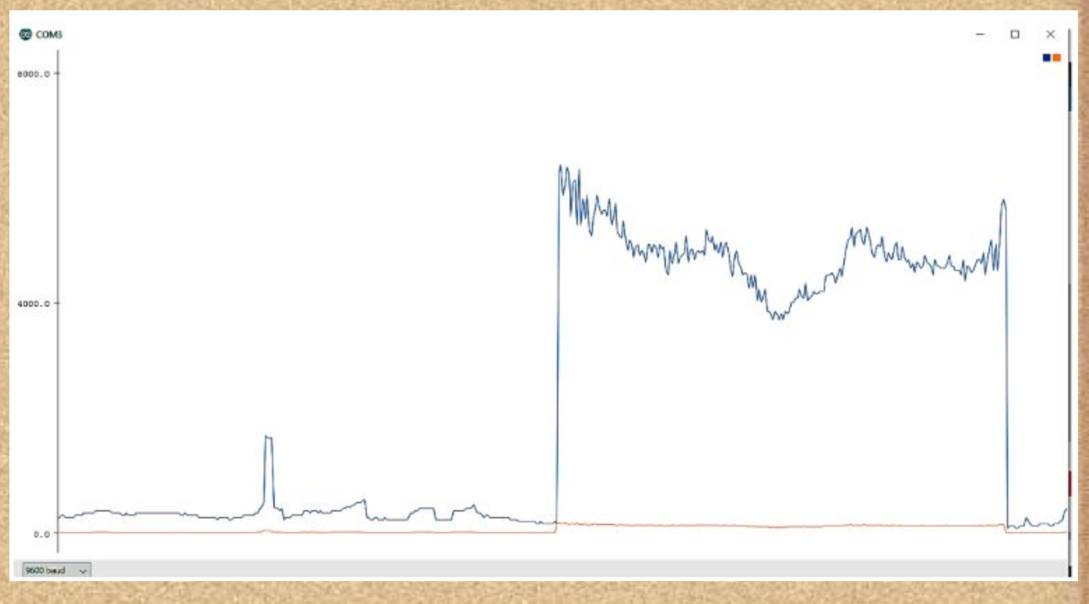


Figure. Xaxis-Movement of the module in whatever direction with time.Yaxis–Distance(Blue) and Tone frequency produced(Orange).

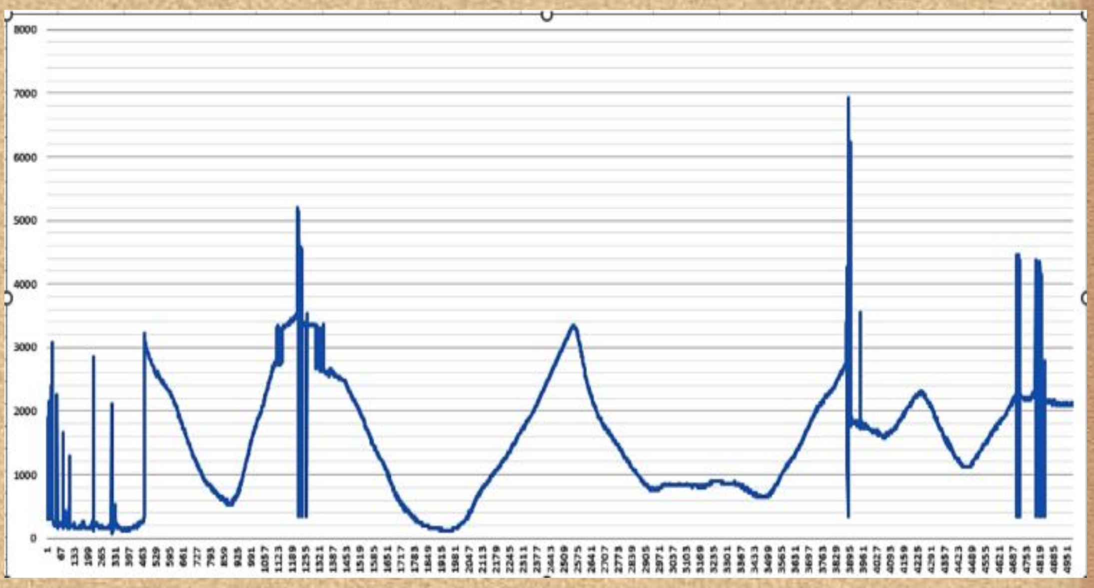


Figure. X axis- Movement of the module in whatever direction with time.Y axis – Frequency of the tone produced in Hertz.

The above graph is an example of data feedback from the Echolocating 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.

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.

Future Plans

- We developed a low cost (Economical), easy to use Echo-locating device for visually impaired person to detect shape, distance and motion of obstacle around.
- Now, our further plan is to create a social enterprise to provide our developed echolocating device to buttom of the pyramid of our society in varanasi with minimal cost.
- Enable GPS tracking functionalities to share the location and path conditions to care taker with alarming system in need of emergency help or support.

References:

Simmons, James A., M. Brock Fenton, and Michael J. O'Farrell. "Echolocation and pursuit of prey by bats." Science 203.4375 (1979): 16-21.

Kolb, Bryan, and Ian Q. Whishaw. "Brain plasticity and behavior." Annual review of psychology 49.1 (1998): 43-64

Cohen, Leonardo G., et al. "Functional relevance of cross-modal plasticity in blind humans." Nature 389.6647 (1997): 180-183.

Acknowledgement

I would like to thanks Prof – Dr.M.Z.Khan sir for allowing us to complete this project under Design and Innovation Hub Summer Projects Programme. And Mr. Nitish Malan(PhD) for his kind support during lab works.