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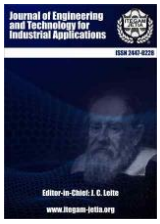

RESEARCH ARTICLE **OPEN ACCESS**

AVEUGLE AIDER ECHOLOCATION BASED SYSTEM FOR BLINDS

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ABSTRACT

One of the most essential and intricate senses we have as humans, is our eyes. It facilitates the perception of light, colour, and depth as well as the visualization of objects. We have the ability to see the things around us but there are people who don't have this ability to enjoy the beauty of nature, who come under the category of BVIPs (Blind and Visually Impaired Persons). They face many challenges in their daily life especially when they traverse around. They will unquestionably need some aid or somebody's help to amble safely. This paper mainly aims at creating a way out to their problem. The idea was inspired from the bat's ability to echolocate obstacles and food. Echolocation is the phenomenon of locating objects based on reflected sound. The paradigm is utilized in the proposed approach to act as a conduit between the blind and their surroundings. Anomalies like obstructions, staircases and damp terrains can all be detected using sensors. For blinds their way of understanding the environment will be through touch and sound. The device helps them to navigate successfully by creating an image of the surrounding in their mind. It is a small handy device that does not hinder other people. Ultrasonic technology and Direct Distance Frequency Synthesizer are the main principles for the device. It is a technique for creating an analogue waveform, typically a sine wave by first creating a time-varying digital signal and then converting it from digital to analogue. Ultrasonic sensors are used as proximity sensors. Our system works similar to that of RADAR. Owing to the technologically advanced era we live in, we decided to assist these people with disability by developing a technology- based solution. It is a useful tool that will be very helpful to blind people.

I. INTRODUCTION

According to the WHO, there are 250 million individuals worldwide who have some form of visual impairment, including about 40 million blind persons. Also, due to age-related diseases like diabetes and glaucoma, these numbers are rising among the ageing population in most countries. Thus, it is increasingly important to develop novel solutions that minimize any potential blindness-related issues while enabling those individuals to engage with sighted people and the visible environment. The capacity to see is one of the most significant features of human physiology.

The window through which we see the world is our eyes. Moreover, 90% of those who are blind live in developing countries. Researching blind people can help us understand how blindness affects how we perceive and think about the world while also allowing us to learn about it via our other senses. These findings are having an impact on the creation of new technology that will help blind people overcome some of the obstacles in their environment.

Being blind or visually impaired does not necessarily prevent you from going anywhere you choose. There are a variety of strategies and techniques that can support people in securely navigating, regardless of their level of vision. With the use of the innovative voice sensory replacement system, blind persons can utilize sounds to construct mental representations of their surroundings.

A walking stick has traditionally been the most popular type of navigational aid for blind persons. However, using it has drawbacks like expense, lengthy, training, and a lack of necessary skills. New inventions and technologies are remoulding the world. Technological breakthroughs have made it possible to design and produce electronic solutions that can help a visually impaired individual navigate without restriction a visually impaired individual navigate without restriction.

Those who are visually challenged are unable to distinguish even the slightest details, even with normal vision Blind people are unable to discern things at a distance of six feet because they have a horizontal vision field of less than or equal to 20 degrees with both eyes open. Assistive technologies are necessary for people with visual impairments. According to, 10% of visually impaired people have no functional vision at all. For persons who have vision impairments, walking in the street can be particularly risky since they have trouble seeing potential hazards in their way. Realizing one's potential and accomplishing one's life goals require a strong sense of autonomy. On the other hand, those who are blind require help from others to carry out daily tasks. Those who are blind or have significant vision loss commonly insist on travelling risky routes when they are alone.

Scientists have been enthralled by bats' use of sound to "see" in the dark for ages. Bats produce ultrasonic chirps, which they use to locate things of interest like food, obstructions, or water resources depending on the timing and shape of the echoes. Mobile robots should be able to localize objectives and barriers in their environment in order to carry out useful tasks like distribution, exploration, and search-and-rescue missions. F. Dümbgen, A. Hoffet et al [1] propose a complete pipeline for sound-based localization and mapping, which is designed for robots with basic buzzers and inexpensive microphones. This method is capable of working in real time, is model-based, and does not require any calibration or training prior to use. The algorithm was tested on the Crazyflie drone and the e-puck robot, which is equipped with integrated audio hardware, and was able to achieve centimetre-level wall localization on both platforms when the robots remained stationary during the measurement process [1]. To pinpoint the location of a reflector, an approximation interference model might be utilized. This algorithm is designed to be used with low-cost, lightweight hardware, and it runs in real time without needing any calibration.

Despite having a simple sonar system with only one transmitter and two receivers, bats are able to navigate in three dimensions by using echolocation. Based on actual behavioural observations of bats during flight, a theoretical research of the 3-D spatial perception technique used by bats has been carried out in Y. Yamada et al [2]. A 3-dimensional localization using information from binaural beats and interaural level differences inspired by bats was achieved. Particular attention was paid to the acoustic information that can be obtained from the "movements" of one's own flight or ear. The results from the output show that binaural beats and interaural level differences help in accurate 3-dimensional localization [2]. In particular, vertical localization using interaural level difference information is proposed as opposed to horizontal localization using interference beat signals. In order to evaluate the proposed methodology, practical experiments were carried out utilising an automatic sensing system with one transmitter and two receivers [2].

Through the usage of healthcare information systems, electronic medical records, wearable, smart, and handheld technologies, the healthcare system is undergoing a digital transition [3]. A navigation system for people with poor vision impairments is one that can provide precise navigational services and can help people avoid obstacles on the way to their destination. The creation of a navigation aid for blind or visually impaired patients is one of the most inspiring applications since it enables them to move around indoors or outdoors without the assistance of others [3]. This paper deals with an efficient way of surveying the different aids available for BVIPs, states the possible challenges regarding bringing these solutions to practicality and avoiding any possible misuse of those and attempts to overcome these by doing literature surveys [3]. A list of relevant keywords, four research questions, criteria for article selection, and a synopsis of the available empirical data are used to carry out this systematic study activity. The researchers and engineers would be able to make more honest conclusions and offer fresh suggestions to benefit the BVIPs by using this systematic mapping [8] shows an integrated framework for use in a mobility aid for the blind that applies cutting-edge computer vision techniques like SLAM and obstacle detection. The navigation tool for the blind presented in [7] uses a microcontroller with synthetic speech output. [9] Suggests creating an electronic white cane that facilitates mobility in both interior and outdoor settings while providing contextualized geographic information by utilizing RFID technology. A walking stick for people who are blind or visually disabled is designed and implemented in [6]. A Crazyflie 2.0 nano quadrotor helicopter (quadcopter) has been introduced as an opensource experimental tool for study and instruction in robotics and control engineering [4]. This article describes the hardware and software of a cheap, readily expandable, and upgradeable flying robot. The article discusses three elements that show how this unmanned aerial vehicle (UAV) could be widely used by academics and students. In order to notify the blind person to obstacles in their path, a buzzer is used in conjunction with an ultrasonic sensor module, model HC-SR04. Deafblind people are an understudied group of disabled people, and [11] has discussed their experiences and attitudes towards assistive communication and mobility devices. It has also demonstrated that deafblind people in the countries studied have a serious problem with rejecting assistive devices, particularly canes and hearing aids, out of fear of stigma, a desire to avoid drawing attention to themselves as disabled, or a lack of acceptance of disability. The white cane is beneficial in alerting its user to any obstacles that are within 1.5 m, however, it does not provide any information regarding the environment beyond that distance. The expense of training a guide dog can reach $42,000, and they are sadly in short supply [12].

An ultrasound obstacle detecting system is suggested that generates, emits, and receives ultrasonic pulses in the air [5]. This article provides a first approximation of the entire system with some evidence in form and composition determination using an easy analysis in the frequency domain. White canes were used in [10] to examine the connection between vibration and the perception of hardness. As part of it, participants in a psychological research were asked to estimate their sense of hardness for each hardness level. It was discovered that the perception of hardness and the frequency of vibration are related. Using temporary deprivation techniques (such as gagging to inhibit the emission of supersonic notes, blindfolding, and ear plugs), the sensory control of obstacle avoidance during flight in a conventional test scenario was studied [13]. It was observer that bats that are wearing blindfolds can navigate obstacles just like regular bats. Avoidance accuracy drops significantly when someone gags or covers their ears. A single ear plug also makes obstacles seem to appear more frequently [13]. Based on multipath propagation inside a room, an approach for concurrent localization and mapping was devised in [14]. A simple sensing setup was used in which it was assumed that there was no pre-installed equipment in the space, only a single omnidirectional sound source, and a single omnidirectional microphone co-located on a robot. It was shown that measuring the distances between the robot and the walls is enough to create an algorithm that properly estimates the robot's trajectory and recovers the geometry of the room [14]. K Ghose et al [15] discuss measurements of the sonar beam pattern of flying echolocating bats, Eptesicus fuscus, performing various insect capture tasks in a large laboratory flight room. The signal strength across a linear array of microphones was used to infer the beam pattern. The findings imply that the axis of the bat sonar beam is a reliable indicator of selective target tracking and, in this regard, is comparable to gaze in animals that rely primarily on vision [15].

II. MATERIALS AND METHODS

Our device enables blind person to move freely and with more accuracy while sensing various obstacles in their path. The hardware components will have connectors for the STM32 Microcontroller Board, the HC-SR04 ultrasonic sensor and other devices. STM32F303RBT7 is the microcontroller found in STM32 Microcontroller Board. An external power source is provided. The system is configured to meet the requirements. The STM32CubeIDE will be used for the programming STM32 Microcontroller Board. The pins of the Microcontroller Board can be configured and so it will be configured according to the need. The gadgets will have external circuits like speakers DAC and power amplifiers.

An intriguing group of animals is the bats, which are one among the few animals that can travel by using echoes. Too many echoes might make a bat’s vision hazy. That’s because these nocturnal animals employ echolocation, a kind of navigation that involves bouncing ultrasonic sound off of their surroundings. These sounds can echo in small spaces, producing a noisy backdrop that obscures the mammal’s auditory vision. Our device uses echolocation as basic principle.

Human hearing typically reaches its maximum frequency at about 20 kHz, whereas echolocation calls are often ultrasonic and range in frequency from 20 to 200 kHz. Yet, we may hear some bats’ echolocation clicks, such as those of the spotted bat. These noises sound like two round stones being struck together. Echolocation calls can typically be identified by their frequency, intensity in decibels (dB), and duration in milliseconds (ms).

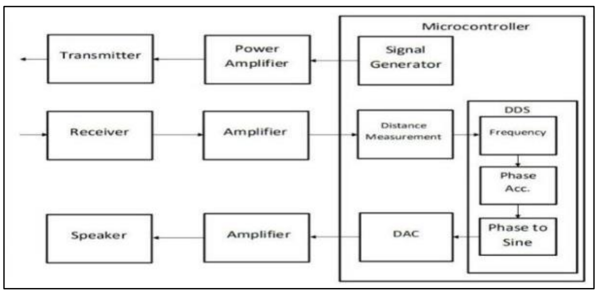

Figure 1: Block Diagram.
Source: Authors, (2024).

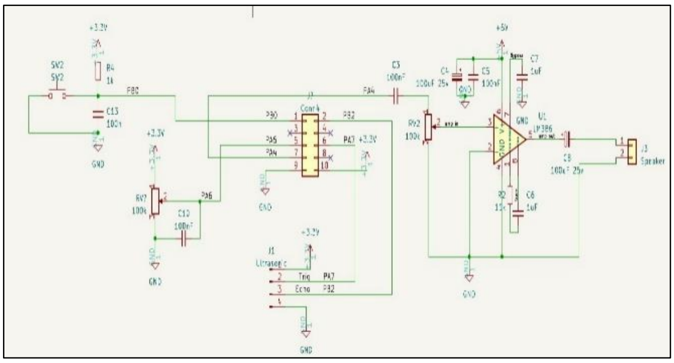

Figure 2: Circuit Diagram.
Source: Authors, (2024).

This system has mainly 3 parts transmission part, receiver part and signal generation part. The design of the device enables the microcontroller to generate a pulse through programming. The power amplifier employed will aid in boosting the signal generated. Ultrasonic trans-receiver modules were positioned to detect obstacles in front, at head level, and at foot level. To Transmit Ultrasonic waves, the timer sent a PWM signal at 100 KHz with a 10 percent duty cycle. To the transmitting end of the US module was delivered the trigger signal. Through input capture control, the transmitted signal that is reflected by the obstruction is received at the echo pin. The information about the obstruction present was then extracted from this echoed signal through analysis. The received signal contained time-related information that was translated into distance using the formula:

$$d = s \times t \tag{1}$$

where d is the distance, s is the speed of sound, t is time duration for the wave to get reflected back.

Here, sound speed is recorded as 340 m/s. The method known as DDS (Direct Digital Synthesizing) will be employed following the distance measurement. Direct digital synthesis (DDS) is a technique used for creating output signals that are frequency and phase-tuneable. The sine LUT was created with 128 samples that stores the sine values and with help of DAC, sine wave is generated. Based on the distance read phase accumulation is done for this above created sine LUT with 128 samples. Timer clock divided by 128 samples gives the frequency of a sinewave. Phase accumulator will then start working. Since the phase accumulator is necessary for producing various sounds for objects at various distances, it will be utilized for addition & multiplication. To vary the frequency from about 100Hz to 3KHz, frequency tune word (ftw) given by,

$$ftw = (f/2^{32})\ fclock \tag{2}$$

where, ftw is the frequency tuning word, f is the frequency, fclock is the internal reference clock frequency.

The obtained ftw is added and multiplied with distance, thus based on the distance it varies between the provided maximum and minimum frequency. If the phase accumulator is absent the device will only produce a single tune and it will not help. After that, the signal will be given to the DAC. The output of the DAC with 3.3volt will be an analogue signal which will be amplified by the op-amp into 5volt and will be given, to the blinds either through a speaker or a headset.

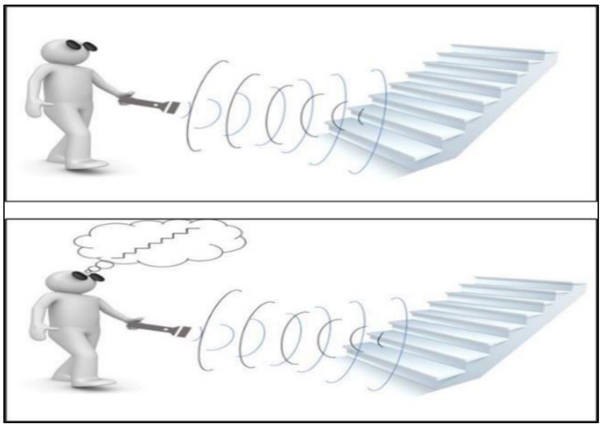

Figure.3: Illustration picture – ultrasonic wave transmitted and received the reflected wave and user gets the idea of obstacle.
Source: Authors, (2024).

III. RESULTS AND FUTURE SCOPE

The STM32 board, power amplifiers, and ultrasonic sensors are tested individually as well as in an integrated system. The ultrasonic sensors operate on the echo principle so, it is crucial to understand how the echo reflects off various object surfaces. The device is made to be light weight so the user is not required to exert themselves more. Also, this device must have a size and shape that defines its portability. The device was tested under various circumstances and corresponding results were obtained. Our device mimics the navigation method from nature i.e., the 3D localization method employed by bat. This technique was investigated and is employed in the project which helps the blinds to navigate properly. It is a small handy device, making it easy for the person to carry the device and use it. Device provides a touch and feel experience to the user on the obstacle in front of them. The project mainly contains three portions transmitter, receiver and sound generation part. method from nature i.e., the 3D localization method employed by bat. This technique was investigated and is employed in the project which helps the blinds to navigate properly. It is a small handy device, making it easy for the person to carry the device and use it. Device provides a touch and feel experience to the user on the obstacle in front of them. The project mainly contains three portions transmitter, receiver and sound generation part.

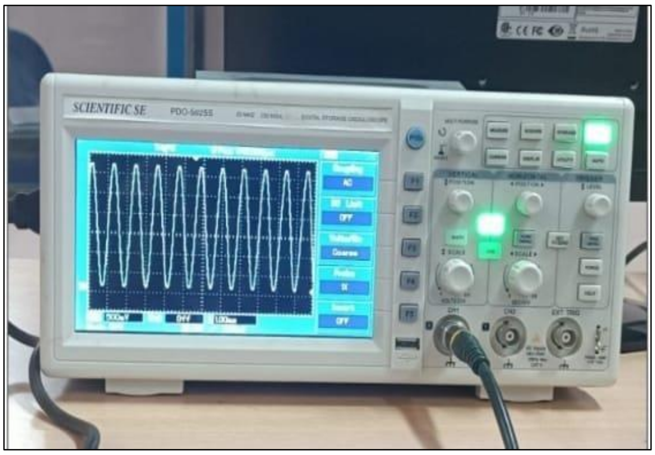

Figure 4: Sine wave generation.
Source: Authors, (2024).

To produce a sine wave, DAC was used, and a sine lookup table was made. An array of 128 sample was included in sine look up table. Combining sine LUT with DAC a perfect sine wave was generated. DSO was set to 2V and sine wave of 3.3V was generated. Sine wave generated and the frequency of the signal from the DDS output is varied. The values are obtained by setting up pre-scalar register value accordingly. Using amplifier, the sound is outputted.

Figure 5: Picture of the device.
Source: Authors, (2024).

Tested the device in various scenarios like different distance, different angles with respect to the obstacle and variation in the frequency is noted.

Case 1: The frequency variation occurring with respect to the distance between the user and obstacle.

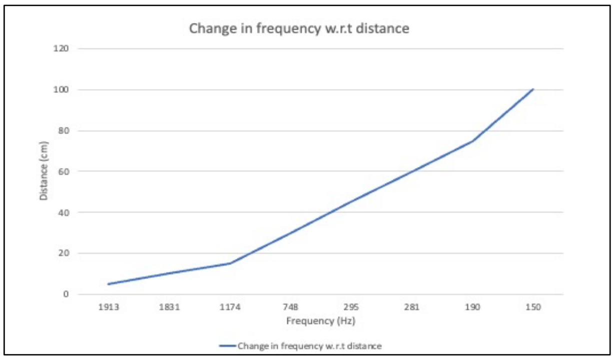

Figure 6: Distance v/s frequency graph.
Source: Authors, (2024).

Case 2: The frequency variation occurring when angle varied and obstacle is static.

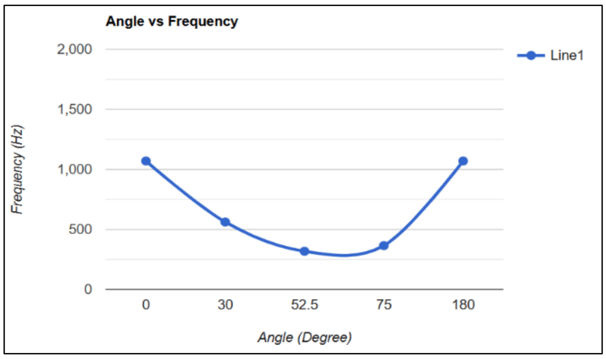

Fig. 7: Frequency v/s angle graph.
Source: Authors, (2024).

We discovered that the HSCR04 sensor functions well within a 30-degree cone after testing in various real-world scenarios. The frequency reduces with changing sensor-to-object angles. However, as the range goes beyond 30 degrees, the sensor's effectiveness drops, interrupting the dropping frequency's natural course, and causing an increase in frequency. Additionally, as the device's distance from a barrier grows, the frequency of the sound it produces appears to be decreasing, and vice versa.
We successfully implemented and tested the prototype with the aid of a micro controller, the DDFS technique, sensors and other contemporary tools. The device offers solutions to blindness-related problems. It provides direction to its users, making navigation simple. There is an audio output unit in the gadget. The device, which resembles a torch, sends out signals and receives them as audio, which gives a notion of the obstacle in front of it. There are certain constraints which can be overcome in future like:

- can add filter to reduce noise and make it more smooth;
- can be integrated further to make it handy, and;
- auto rotation of the sensor.

IV. CONCLUSIONS

Being blind is viewed as a curse in society. People who are blind encounter many challenges every day, due to which they lose their sense of self-worth and start to feel like a hindrance to social and economic advancement, killing their impulse for living. They struggle to perform daily tasks due to a variety of challenges they deal with. The amount of data necessary for the safe movement of BVIPs could not be provided by the usual navigational aids. This is the reason behind our decision to use it as the foundation of our system. The device specified in this article mimics the navigation method from nature i.e., the 3D localization method employed by bat. This technique was investigated and is employed in the project which helps the blinds to navigate properly. The project mainly contains three portions: transmitter, receiver and sound generation part. There is an audio output unit in the gadget. The device sends out signals and receives them as audio which can be interpreted by the user, which gives a notion of the obstacle in front of it. We successfully implemented and tested the prototype with the aid of a micro controller, the DDS technique, sensors and other contemporary tools. The device was tested and analysed on various scenarios such as variation of distance between the obstacle and the device, the variation of the frequency of the sound when the device is kept at different angles with respect to the obstacle. Through the real time testing the efficiency, behaviour and relevance of the system was found to be near accurate, with possibilities of future enhancement. A device of this nature makes a significant contribution to human welfare.

V. AUTHOR'S CONTRIBUTION

Conceptualization: Neetha K, Abirami K A, Amrutha P P, Andria Raju and Atulya G Nair.
Methodology: Abirami K A, Amrutha P P.
Investigation: Andria Raju and Atulya G Nair.
Discussion of results: Neetha K, Abirami K A, Amrutha P P, Andria Raju and Atulya G Nair.
Writing – Original Draft: Neetha K, Abirami K A, Amrutha P P.
Writing – Review and Editing: Neetha K, Abirami K A, Amrutha P P, Andria Raju and Atulya G Nair.
Resources: Abirami K A, Amrutha P P, Andria Raju and Atulya G Nair.
Supervision: Neetha K.
Approval of the final text: Abirami K A, Amrutha P P, Andria Raju and Atulya G Nair.

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