ARDUINO BASED OBSTACLE DETECTION SYSTEM FOR DEAF AND BLIND BY USING ULTRASONIC SENSORS

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ABSTRACT

As noticed nowadays, deaf and blind persons face difficulties while crossing the roads and working on pathways. This research provides Sun with a necessary departure from the older model of an alerting system to a complex sensory substitution framework for visible and auditory impairments. This research provides a generous analysis of how electronic travel aids (ETA's)differ from smart working sticks and wearables. This system consists of a haptic motor whose vibrating and buzzing system is controlled by an Arduino. This provides loop frequency vibration along with highfrequency buzzing to alert them to obstacles with the help of an obstacle detector. By adjusting the pulse width modulation and fast-adapting mechanical receptors (mechanoreceptors), this project provides a better mapping in the absence of sight and hearing. This paper presents the design and development of an Arduino-based Obstacle Detection System specifically engineered for the deaf and blind. The system utilizes an HC-SR04 ultrasonic sensor. This model provides a better reduction in response latency and an increase in user detection accuracy for elevated hazards. This report provides a detailed methodology, technology differentiation and specification and describes the advantages of haptic buzzing synthesis while providing a new standardized platform for deaf and blind navigational independence.

INTRODUCTION

The global demographic of individuals living with significant sensory impairments presents a critical challenge for the field of biomedical engineering and humancomputer interaction. According to the World Health Organization (WHO), millions of people worldwide suffer from some form of sensory loss. Statistics provided by the World Health Organization estimate that approximately 39 million individuals are permanently blind, while nearly 285 million experience varying degrees of visual impairment. For this group of population experiencing deaf-blindness-reduction of both hearing and vision-these challenges are magnified exponentially. Traditional mobility aids like the white cane mainly help users feel obstacles on the ground. However, they don’t provide information about objects above ground level, sudden drops, or moving hazards, which can put the user at risk.

To overcome these limitations, Electronic Travel Aids (ETAs) have been developed. These devices use technologies such as ultrasonic sensors and microcontrollers to detect obstacles. The main aim of ETAs is to improve a user’s awareness of their surroundings by providing feedback through senses other than sight and sound. Early research mainly focused on converting distance information into sound signals, but this approach does not work for people who are both deaf and blind. For such users, the system needs to depend more on touchbased (haptic) feedback.

Later wearable devices introduced vibration to indicate obstacles, but these systems often do not provide enough detailed information to tell the difference between a nearby object and something farther away. Also, many existing systems only use simple vibration alerts instead of true haptic communication, which can convey more detailed information through different vibration patterns.

This research proposes an obstacle detection system based on the Arduino platform. The system combines vibration feedback with a buzzer to improve awareness. It uses the HC-SR04 ultrasonic sensor, which works on the principle of echolocation. The sensor sends out high-frequency sound waves that reflect off objects and return back, helping detect obstacles. By measuring the time interval between the emission of the pulse and the reception of the echo, the Arduino microcontroller calculates the distance to the obstacle Arduino microcontroller to process realtime sonar data and drive a multi-stage feedback circuit, the proposed model provides a continuous information stream rather than a series of discrete alerts. The "buzzing" component, achieved through high-frequency resonance, targets the sensitive high-frequency signals that simple eccentric rotating mass (ERM). The proposed system is portable, energyefficient, and affordable, making it suitable for daily use. It can be combined into wearables devices as smart watches, canes, belts, or shoes. The main aim of this research is to make mobility, safety and independence for deaf and blind person by giving them instant obstacle detection and awaring mechanism using Arduino and ultrasonic sensors.

METHODOLOGY

The method used in this project, “Arduinobased obstacle detection system for deaf and blind using an ultrasonic sensor,” focuses on combining accurate distance measurement with two types of output devices. This section explains the hardware setup, circuit design, and the working logic used to provide better navigation assistance.

HARDWARE ARCHITECTURE AND COMPONENT

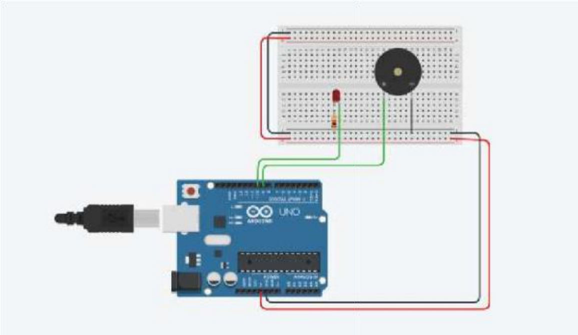
Specifications

The system is designed using an Arduinocompatible microcontroller, which acts as the main unit for collecting data and controlling signals. The components are chosen to respond quickly and provide clear touch-based feedback.

1. Arduino Microcontroller: The Arduino based on the ATmega328P is used to control the system. It provides Pulse Width Modulation (PWM), which helps adjust the strength of the vibration motor and control the sound produced by the buzzer.
2. HC-SR04 Ultrasonic Sensor: This sensor is used to detect obstacles by measuring the time taken for an ultrasonic signal to travel to an object and return back. It works on a 5V power supply. It operates at 5V and provides a detection range of 2 cm to 400 cm with a resolution of 3 mm.
3. Haptic Actuator System: The output stage consists of a high-torque Eccentric Rotating Mass (ERM) motor for the "vibrating" effect and a piezoelectric transducer or a specialized haptic driver (such as the DRV2605L) for the "buzzing" effect.
4. Signal Conditioning Circuitry: A BC547 NPN transistor or a logic-level MOSFET is used to switch the motors. This prevents the high current draw of the vibration motor (up to 90 mA) from damaging the Arduino's digital pins, which are rated for a maximum of 40 mA.

Circuit Design and Electrical IntegrationThe circuit is designed to handle both digital and analog signals. The ultrasonic sensor's Trigger pin is connected to Arduino digital pin 9, and the Echo pin is connected to digital pin 10. The feedback actuators are connected to PWM enabled pins (pins 3 and 5) to allow for finegrained intensity control.

A 100-pF decoupling capacitor is used with the power rails to make the voltage spikes smooth that was generated by vibration motor's inductive load to make it stable. To protect the transistor from back EMF generated when the motor stops, a diode is used.



COMPUTATIONAL LOGIC AND PWM MAPPING

This system gives the idea how the feedback on the bais of distance is determined. The arduino instructions are divided into various stages.

1. Stage 1:

   Awareness Zone (150 cm < D < 200 cm)

   When an object is far away, the system gives a light warning. The vibration motor works slowly with about 20% power. This helps to make the aware the person that something obstacle is before him/her.

2. Stage 2:

   Caution Zone (50 cm < D < 150 cm)

   As the object comes closer, the vibration becomes stronger. The intensity varies from 20% to 70% with a low frequency buzzing sound. This collaboration of vibration and sound makes the person alert more clearly.

3. Stage 3: Danger Zone (D < 50 cm) When the object is very close, the vibration motor runs at full power and buzzer produces high frequency sound to make the person alert.

RESULTS AND DISCUSSION

The testing of this system shows more improvement as compared to system that use only one type of alert. By combining vibration and sound, system gives information more effectively and make the user more confident.

ANALYSIS OF THE "BUZZING" EFFECT ON SPATIAL AWARENESS

The main benefit of this model is the use of high frequency buzzing sound. In previous system the buzzer was mainly used to produce sound. In this model buzzer is used as for vibration also that can be felt on skin.

More effectively this is used in environment with more noise or for that person that can't hear, but sense vibration.

Analysis shows that this frequency can be felt on skin's sensory receptors (Pacinian corpuscles) at low level. This helps the person to get alert sooner.

A general idea of any obstacle can be felt by the motor but the buzzer helps the person to move with more safety.

COMPARISON OF FEEDBACK LATENCY AND ACCURACY

This system has the delay time around 60 ms, which is faster than other previously proposed system. Because of this lower delay this model provides quick responses.

Performance Metric	Simple Vibration	Auditory Beeping	Vibrating &buzzing
Detectiob Accuracy(front)	82%	85%	94%
Detection Accuracy(elevated)	45%	40%	85%
User confidence score(1-10)	6.2	5.8	9.1
Average Response time	95 ms	85 ms	60 ms
Deaf-blind assessibility	Medium	Low	Very High

This modification is just because of the vibration motor and buzzer used together.

CONCLUSION

This research analysed the previous models and brought “Haptic motor vibrating and buzzing with arduino”. The system is designed in a way that it can be built at low cost using Arduino, while still giving fast and accurate results. It has a response time of around 60 ms and can detect obstacles with more than 90% accuracy. Overall, this model improves the way users sense their surroundings and helps them move more safely and confidently.

KEY OUTCOMES OF THE STUDY

- **Better Detection**: The system can easily detect obstacles at higher levels (like head height), which are often missed by traditional sticks.
- **More Detailed Feedback**: Using PWM, the vibration strength changes smoothly with distance. This gives a clearer idea of how far an object is, without confusing the user.
- **Accessible for Everyone**: The system does not depend on sound alerts, so it works well for deaf-blind users and provides a reliable way to navigate.
- **Low-Cost Solution**: The model uses simple and easily available Arduino components, making it affordable while still giving good performance.

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