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Glasses for People with Visual and Hearing Impairment

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ABSTRACT

Background: Individuals with both visual and hearing impairments face significant mobility challenges. Traditional aids such as canes and guide dogs provide limited support, necessitating innovative assistive technologies to enhance independent navigation. Purpose: This study aims to develop and evaluate smart glasses integrating ultrasonic sensors and haptic feedback to assist individuals with dual sensory impairments in detecting obstacles and improving mobility. Methods: A single case study assessed the effectiveness of the glasses. The prototype employs ultrasonic sensors for obstacle detection and a microcontroller to process data, triggering vibrations for user alerts. Testing in controlled and real-world environments evaluated detection accuracy, usability, and user experience. Results: The glasses effectively detected obstacles and provided real-time haptic feedback, enhancing spatial awareness. Participants reported improved confidence and ease of navigation. The lightweight, ergonomic design ensured comfort and practicality. Conclusion: These smart glasses present a promising assistive technology for individuals with visual and hearing impairments. By providing real-time haptic feedback, they enhance mobility and independence, demonstrating the potential of wearable technology in rehabilitation and assistive care.

INTRODUCTION

The World Health Organization estimates that 2.2 billion people globally experience vision impairment or blindness, with 1 billion cases either preventable or remaining unaddressed. Additionally, approximately 1.5 billion individuals are affected by some form of hearing loss, of which 430 million suffer from disabling hearing loss requiring rehabilitation (World Health Organization, 2024). Studies show that 90% of the world's visually impaired population resides in low-income settings, and 82% of those living with blindness are aged 50 and above (Kankariya et al., 2024). India has become the country with the largest population of blind individuals worldwide, accounting for over 15 million out of the global 37 million visually impaired people (Bhuniya et al., 2017; Kankariya et al., 2024).

Individuals with visual impairments often depend heavily on external assistance to navigate their environments, as their inability to perceive and respond to obstacles significantly limits their mobility, independence, and safety. Traditional mobility aids, such as white canes and guide dogs, play essential roles but offer limited support, relying largely on the user's ability to interpret their surroundings (Kankariya et al., 2024). These limitations become more evident in complex or unfamiliar environments, where the risk of collisions and injuries increases. As global attention toward inclusivity and accessibility continues to grow, there is a pressing need for advanced assistive technologies that empower individuals with visual and hearing impairments to navigate their environments more independently and confidently.

Over the years, various technological interventions have been introduced to bridge this gap. However, traditional assistive devices like white canes come with inherent limitations, and range sensor technologies, such as infrared sensors, often encounter issues like ghost echoes and are influenced by factors such as stride cycles during walking (Ong et al., 2013). Other challenges include inaccuracies, false alerts, misidentification of obstacles, and ergonomic issues leading to user discomfort (Bhuniya et al., 2017; Ong et al., 2013). Among emerging technologies, ultrasonic sensors have shown promise in detecting obstacles and providing real-time feedback to users. Early implementations embedded these sensors into handheld or wearable devices—such as vests and belts—which communicated information through

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vibrations or audio signals (Okolo et al., 2024; Ong et al., 2013). While these developments marked significant progress, they too have drawbacks. Handheld devices require active user engagement and occupy one hand, limiting multitasking, whereas wearable systems, despite being hands-free, often consist of bulky components and generate continuous vibrations or sounds, leading to discomfort and reduced user acceptance (Kankariya et al., 2024; Pydala et al., 2023).

This study seeks to overcome these challenges by designing a more compact and user-friendly assistive solution aimed at individuals with visual and/or hearing impairments. The proposed system incorporates ultrasonic sensors to detect obstacles and utilizes vibrating motors connected to a microcontroller (Arduino Nano) mounted on the temples of a pair of glasses. This configuration allows for obstacle detection from the front, left, and right within a defined distance range, enhancing situational awareness without compromising comfort or usability.

METHOD

This study aims to design, develop, and evaluate the effectiveness of Obstacle-Detection Glasses in enhancing the mobility, safety, and independence of individuals with visual and hearing impairments.

Objectives

To provide haptic feedback (e.g.; vibration) and alerts on the glasses to indicate the presence of obstacles.
To ensure the system is lightweight, comfortable, and easy to use for individuals with visual and hearing Impairments.

Research Design

Single Case Study.
This research employs a single case study design to evaluate the effectiveness of obstacle-detection glasses for individuals with dual impairments. A single participant is selected to test the device. The study involves training the participant to use the glasses, which are equipped with sensors for obstacle detection and vibration motors for tactile feedback. Testing is conducted in controlled environments and real-life scenarios to assess the glasses impact on mobility, safety, and independence. Quantitative data, such as obstacle detection accuracy, and qualitative feedback on usability and comfort, are collected and analyzed to determine the device's practicality and effectiveness.

Data Collection

Quantitative Data

1. Obstacle detection accuracy
2. Time taken to detect and respond to obstacles.

Qualitative Data

Participant feedback on comfort, usability, and perceived safety improvements.

Data Analysis

The Data Analysis focuses on evaluating the effectiveness, accuracy, usability, and user satisfaction of the obstruction detection glasses.

Design Concept

1. The design concept focuses on creating a lightweight, comfortable, and user-friendly device integrating an ultrasonic sensor and Arduino Nano Microcontroller that enhances navigation and safety through sensor technology and feedback mechanisms.
2. Detect obstacles within a 0.8-meter range (80 cm) and deliver feedback.
3. The glasses should resemble regular eyeglasses or sunglasses ensuring familiarity and comfort for the user.
4. They will be lightweight and ergonomically designed and suit various face shapes.

Field Testing

1. Deploy the glasses in controlled environments (indoor and outdoor).
2. Measure detection accuracy, response time, and user feedback.

Feedback system

Small Vibrating motors (Coin Vibration Motor flat 1034 Mobile Phone Vibrator Motor) placed on the frame.

Functionality

1. **Obstacle Detection**: The sensors continuously scan the environment in front of the user, identifying obstacles within a certain range.
2. **Distance Sensitivity**: The feedback strength (vibration intensity) increases as obstacles get closer, providing real-time information on the proximity of potential hazards.
3. **Energy Efficiency**: The glasses will enter a low latency mode when no movement is detected, preserving battery life and allowing for extended use.

User Experience

1. **Intuitive Alerts**: The vibration helps users to interpret their environment quickly and intuitively, even without audio feedback.
2. **Comfort and Discretion**: The device will look similar to ordinary eyewear avoiding a "medical device" appearance and promoting user confidence in public spaces.
3. **Ease of Use**: The device is turned on with a single button and requires minimal user setup making it accessible for users.

Design: Pre-test Post-test Design

In a pre-test-post-test design, complete specific tasks or tests before using the obstacle-detection glasses (pre-test) and then repeat similar tasks with the glasses (post-test).
By comparing performance in both conditions, this design helps identify any navigation and safety improvements directly associated with the device.

Monitoring and Auditing

The study was monitored by the research team to ensure adherence to procedures and data accuracy. Regular audits of the device's performance and participant safety were conducted throughout the testing process.

Key Components

The Specification of contents is obtained from (16).

1. **Sensors**: Ultrasonic sensors (Ultrasonic Module HC-SR04 Distance Measuring Sensor) embedded in the frame to detect obstacles within a specific range, particularly at the head level.
2. The HC-SR04 is an affordable and easy-to-use distance-measuring sensor with a range from 2cm to 400cm (about an inch to 13 feet).
3. It weighs approximately 25 grams, with a height of around 1 centimeter and a width of about 2 centimeters.

The sensor is composed of two ultrasonic transducers. One is a transmitter that outputs ultrasonic sound pulses and the other is a receiver that listens for reflected waves.



Figure 1. Ultrasonic Sensor HC-SR04

Emitter Configuration

1. **Component**: Piezoelectric transducer.
2. **Frequency**: Emits ultrasonic waves at 40 kHz.
3. **Working Principle**: Converts electrical signals into sound waves. A short electrical pulse (10 µs trigger) causes the emitter to generate a burst of ultrasonic sound waves.

Receiver Details

1. **Component**: Another piezoelectric transducer.
2. **Function**: Detects ultrasonic waves reflected from an object.
3. **Working Principle**: Converts the received ultrasonic waves back into electrical signals.
4. **Sensitivity**: Optimized for the 40 kHz frequency to ensure accurate detection

Working Mechanism

1. **Trigger Signal**: The sensor is triggered using a 10 µs HIGH signal on the TRIG pin.
2. **Ultrasonic Pulse**: The transmitter emits a burst of 8 ultrasonic waves at 40 kHz.
3. **Echo Detection**: The receiver waits for the reflected wave (echo).
4. **Time Measurement**: The sensor outputs a HIGH pulse on the ECHO pin for the duration of time it took for the ultrasonic wave to return.

Arduino Nano Micro-controller

1. The Arduino Nano is a small, complete and breadboard-friendly board based on the ATmega328p processor
2. Operating Voltage is 5V
3. Input Voltage (Vin) is 7-12 V
4. Input/ Output pins are 22
5. Analog I/P pins are 6 from A0 to A5
6. Digital Pins are 14
7. Power Consumption is 19mA
8. I/P pins DC Current is 40mA
9. Flash Memory is 32kb
10.SRAM is 2kb
11.EEPROM is 1kb
12. Frequency (Clock speed) is 16 MHz
13. Weight- 7g

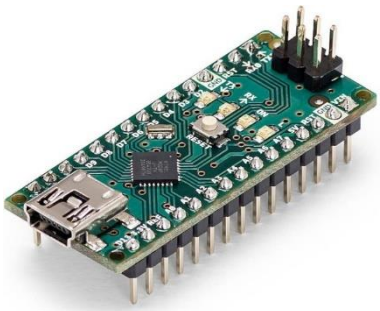


Figure 2. Arduino Nano Microcontroller

LiPo battery 3.7 V

1. Ultra-thin design
2. Nominal Voltage: 3.7 V
3. Nominal Capacity: 80mAh
4. Low internal resistance
5. Good cycle life
6. Optimized PCM design
7. In series connection or parallel connection is allowed
8. Excellent safety.
9. One full cycle of the battery will last around 2 hours and takes approximately 2-3 hours to get fully charged.



Figure 3. 3.7V LiPo battery

TP4056 Battery Charging Module Type C

1. The TP4056 Battery Charging Module Type C is for Li-Ion Battery Charging
2. It is a Type C with Current Protection that is perfect for charging single cell 3.7V 1 Ah or higher lithium-ion (Li-Ion) cells such as 16550s that don't have their own protection circuit.
3. It is based on the TP4056 charger IC and DW01 battery protection IC and provides 1A Charge Current.



Figure 4. TP4056 Battery Charging Module Type C

Infrared (IR) Proximity Sensor

1. Used to detect objects and obstacles
2. It keeps emitting Infrared waves
3. Voltage range- 3.3 V – 5V



Figure 5. IR Proximity Sensor

Vibrator Motor 5V

1. A 5V vibrator coin point typically refers to a small, disc-shaped vibration motor powered by 5 volts**.**
2. Voltage: Operates at 5V (often powered by USB or a small power supply).
3. Current Draw: Typically low, often under 100mA.
4. Size: Compact, with diameters ranging from 8mm to 20mm, depending on the model.
5. Speed: Measured in RPM (Revolutions Per Minute), ranging from 10,000 to 15,000 RPM.

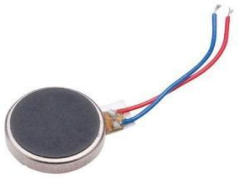


Figure 6. Vibrator Motor 5V

MT3068 Boost Converter

The MT3068 is a DC-DC boost converter integrated circuit commonly used to step up a low input voltage (e.g., 3.7V from a lithium-ion battery) to a higher output voltage, such as 5V, suitable for USB-powered devices.



Figure 7. MT 3068 Boost Converter

Wires and Connectors

Wires are conductive materials, usually made of metals like copper or aluminum, designed to carry electrical currents or signals. Their main functions include:

Power Transmission

1. Carry electrical current from a power source to a device or circuit.
2. Used in power grids, appliances, and industrial machinery.

Signal Transmission

Transmit analog or digital signals in communication systems, audio systems, and other electronics.



Figure 8. Wires and Connectors

Glass Frame

Protect the eyes from a variety of hazards and all the components are attached to the frame of the glass.



Figure 9. Glass Frame

PROCEDURE

Components Required

1. Ultrasonic Sensor (HC-SR04)
2. Arduino Nano Microcontroller
3. 5V Vibrator Motor
4. 3.7V LiPo Battery
5. TP4056 Battery Charging Module (Type C)
6. MT3608 Boost Converter (3.7V to 5V)
7. Wires and Connectors
8. Eyewear Frame (to mount components)
9. Electronic Instrument Silicone Adhesive Sealant
10. Soldering Tools
11. Electrical Tape (for insulation)

The first step in creating obstruction detection glasses is to collect the necessary parts: an Arduino Nano microcontroller, a 5V vibrator motor, a 3.7V LiPo battery, a Type C TP4056 battery charging module, an MT3608 boost converter (3.7V to 5V) wires, connectors, and a mounting frame for eyeglasses. Begin by preparing the ultrasonic sensor, connecting its TRIG and ECHO pins to digital pins on the Arduino Nano (e.g., D2 and D3), and its VCC and GND pins to the 5V output and GND respectively from the MT3608 boost converter. The next step is to integrate the vibrator motor by connecting one terminal to a digital pin on the Arduino (D9) and the other to GND. For power, connect the 3.7V LiPo battery to the TP4056 module (B+ to the battery's positive terminal and B- to the negative), and then link the TP4056's output (OUT+ and OUT-) to the MT3608 boost converter input. Adjust the MT3608's output to 5V using its potentiometer and connect it to the Arduino's VIN and GND pins for powering the microcontroller and sensor. Mount the ultrasonic sensor at the front of the eyewear frame and the vibrator motor near the temples for tactile feedback. Write and upload a program using the Arduino IDE Software to Arduino Nano that measures distance using the ultrasonic sensor and activates the motor if an obstacle is detected within a predefined range(1metre), 39.37 inches). Secure all components neatly onto the frame, using wires and connectors for interconnections, using Electronic Instrument Silicone Adhesive Sealant and insulate exposed connections with electrical tape. Test the system to ensure it works as intended, adjusting the code or sensor placement for optimal performance. Finalize the assembly by soldering connections for durability, ensuring all components are securely attached, and charge the battery regularly through the TP4056 module for consistent operation and add a power switch between the battery and the TP4056 for easier ON and OFF Control.

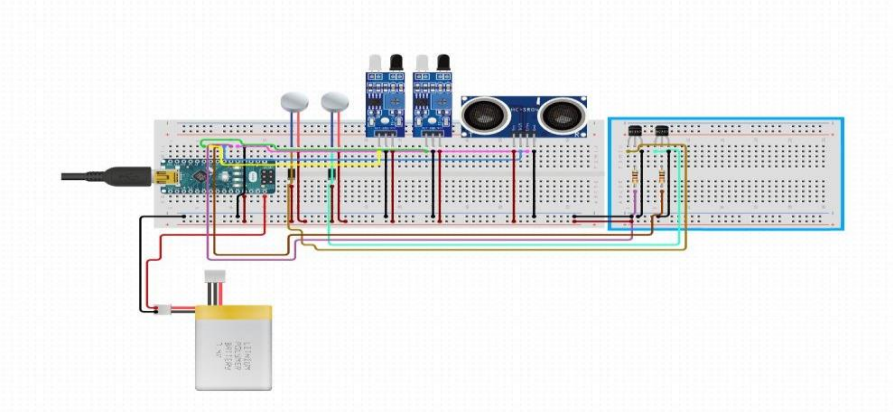
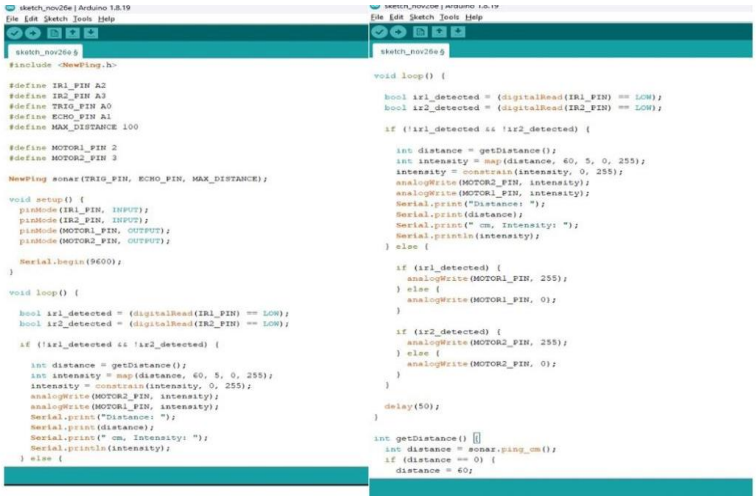


Figure 10. Circuit Diagram



```
#include <NewPing.h>

#define IR1_PIN A2
#define IR2_PIN A3
#define TRIG_PIN A0
#define ECHO_PIN A1
#define MAX_DISTANCE 100

#define MOTOR1_PIN 2
#define MOTOR2_PIN 3

NewPing sonar(TRIG_PIN, ECHO_PIN, MAX_DISTANCE);

void setup() {
  pinMode(IR1_PIN, INPUT);
  pinMode(IR2_PIN, INPUT);
  pinMode(MOTOR1_PIN, OUTPUT);
  pinMode(MOTOR2_PIN, OUTPUT);

  Serial.begin(9600);
}

void loop() {

  bool ir1_detected = (digitalRead(IR1_PIN) == LOW);
  bool ir2_detected = (digitalRead(IR2_PIN) == LOW);

  if (!ir1_detected && !ir2_detected) {

    int distance = getDistance();
    int intensity = map(distance, 60, 5, 0, 255);
    intensity = constrain(intensity, 0, 255);
    analogWrite(MOTOR2_PIN, intensity);
    analogWrite(MOTOR1_PIN, intensity);
    Serial.print("Distance: ");
    Serial.print(distance);
    Serial.print(" cm, Intensity: ");
    Serial.println(intensity);
  } else {

    if (ir1_detected) {
      analogWrite(MOTOR1_PIN, 255);
    } else {
      analogWrite(MOTOR1_PIN, 0);
    }

    if (ir2_detected) {
      analogWrite(MOTOR2_PIN, 255);
    } else {
      analogWrite(MOTOR2_PIN, 0);
    }
  }

  delay(50);
}

int getDistance() {
  int distance = sonar.ping_cm();
  if (distance == 0) {
    distance = 60;
```

Figure 11. Arduino IDE Programming



Figure 12. Prototype Design

TESTS

Static Obstacle Detection test: Place the stationary obstacles at varying distances in a controlled space to test the glasses' ability to detect the barriers and provide tactile feedback.

Dynamic Obstacle Detection test: Introduce moving obstacles to assess the glasses' responsiveness to dynamic objects.



Figure 13. Static Obstacle Detection test



Figure 14. Static Obstacle Detection test



Figure 15. Dynamic Obstacle Detection test

The research on obstruction detection glasses for individuals who are blind and deaf demonstrated the effective integration of ultrasonic sensors and tactile feedback systems to assist in obstacle detection. The device accurately identified nearby obstacles and conveyed proximity information through vibrations, ensuring reliable spatial awareness without relying on visual or auditory cues. The lightweight, wearable design, combined with efficient power management, made the glasses practical for daily use.
The result highlights the potential of such assistive technology to enhance independence and safety for individuals with dual sensory impairments.

DISCUSSION

Mobility and spatial awareness pose significant challenges for individuals with both visual and hearing impairments. Traditional mobility aids, such as white canes and guide dogs, provide essential support but have limitations, particularly in complex or unfamiliar environments. With advancements in assistive technology, wearable devices integrating sensor-based feedback have emerged as a promising solution to enhance independent navigation for individuals with dual sensory impairments. This study focuses on the development and evaluation of Obstacle-Detection Glasses, which use ultrasonic sensors and haptic feedback to assist users in detecting obstacles. The glasses provide real-time tactile feedback, eliminating the need for auditory cues. This feature is particularly beneficial for individuals who rely solely on touch-based perception for navigation. By detecting obstacles from a distance and conveying warnings through vibrations, the glasses enhance the user's ability to move confidently and safely. The results demonstrate that the Obstacle-Detection Glasses effectively identify obstacles and communicate their presence via haptic feedback. Compared to traditional canes, which require direct contact with an object before detection, the ultrasonic sensors in these glasses enable early obstacle detection, allowing users more time to react and adjust their path. This capability significantly reduces the risk of collisions and injuries, particularly in crowded or unfamiliar environments. Additionally, the lightweight and compact design of the glasses ensures user comfort and practicality, addressing common concerns associated with bulky or inconvenient assistive devices. Despite their advantages, the study also identifies certain limitations. The effectiveness of ultrasonic sensors can vary depending on environmental factors, such as the presence of reflective or absorptive surfaces, which may interfere with accurate obstacle detection.

Additionally, the device requires regular charging, as its battery life is currently limited. Addressing these issues through future technological improvements such as enhanced sensor calibration, increased power efficiency, and longer battery life could improve the device's reliability and practicality. Another limitation is the scope of this study, which is based on a single case. The findings, therefore, cannot be generalized to the broader population of individuals with visual and hearing impairments. Future research should include larger sample sizes and diverse user groups to validate the effectiveness of the device under different conditions and user preferences. Furthermore, refining the design for improved ergonomics and exploring additional feedback mechanisms such as AI-based navigation assistance could further enhance the device's usability and efficiency. In conclusion, the Obstacle-Detection Glasses present a promising innovation in assistive technology, offering a practical solution to enhance mobility and independence for individuals with dual sensory impairments. While certain challenges remain, continued technological advancements and larger-scale testing could pave the way for widespread adoption. With further improvements, these glasses have the potential to significantly enhance the quality of life for individuals with visual and hearing impairments.

CONCLUSION

Obstruction detection glasses for the blind offer a practical and innovative solution to enhance mobility and independence by providing real-time tactile feedback about nearby obstacles. Utilizing accessible technologies like ultrasonic sensors, microcontrollers, and vibration motors. These glasses bridge sensory gaps and improve spatial awareness. While challenges such as compact integration and environmental variations exist, careful design and future advancements can address these issues. This research highlights the potential of assistive technology to transform the lives of visually impaired individuals, promoting autonomy and safety in everyday navigation.

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