



Mini Project Report

SightShift: Smart Cane for the Visually Impaired

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CERTIFICATE

Certified the project work entitled "**SightShift: Smart Cane for the Visually Impaired**" carried out Rishi Raj - 1MS23ET069, bonafide students of Ramaiah Institute of Technology, Bangalore, in partial fulfilment for the award of Bachelor of Engineering in Telecommunication Engineering of the Visveswaraiah Technological University, Belgaum during the year 2024-2025. The project report has been approved as it satisfies the academic requirements in respect of mini project work for the course Microcontrollers

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DECLARATION

I hereby declare that the project entitled "SightShift: Smart Cane for the Visually Impaired" has been carried out by me, under the guidance of Dr. S G Shivaprasad Yadav, Associate Professor, Department of Electronics & Telecommunication Engineering, Ramaiah Institute of Technology, Bangalore. This report has been submitted in partial fulfilment for the award of grades in the course "Microcontrollers" during the year 2024-2025.

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ABSTRACT

This project introduces *SightShift*, a smart cane designed using ultrasonic sensors and an Arduino microcontroller to enhance the mobility and safety of visually impaired individuals. According to the World Health Organization, approximately 37 million people worldwide are blind and often rely on external support such as caretakers, guide dogs, or assistive devices. To address the limitations of traditional mobility aids, we developed a technologically advanced yet cost-effective smart cane that detects obstacles and alerts the user through multiple feedback modes.

Ultrasonic sensors are strategically positioned on the cane to scan the surrounding environment. When an obstacle is detected, the system activates a buzzer, a vibration motor, and an LED to provide immediate audio, tactile, and visual cues. The SightShift cane is lightweight, power-efficient, and capable of detecting obstacles up to 4 meters ahead. Built on an Arduino platform and programmed in embedded C, the device was rigorously tested and demonstrated reliable performance in real-world conditions. Our design offers a practical, user-friendly mobility solution, aiming to empower the visually impaired with greater independence and confidence.

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Introduction

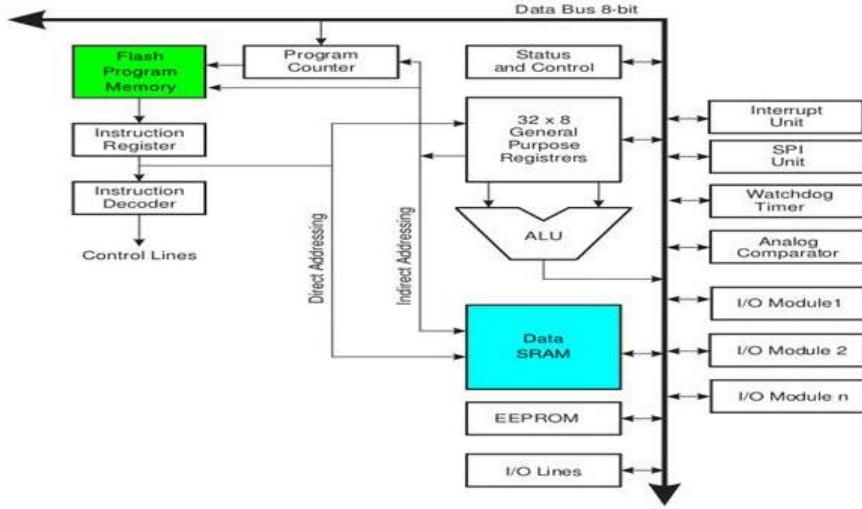
Visually impaired individuals experience significant challenges in perceiving and navigating their surroundings. According to the World Health Organization (WHO), visual acuity less than 6/60 or a visual field less than 20 degrees with both eyes open qualifies as blindness. A 2011 WHO report estimated that approximately 70 million people worldwide live with some form of visual impairment, including 7 million who are completely blind.

For many, mobility is heavily dependent on assistance from caregivers, guide dogs, or traditional white canes. However, conventional canes are limited by their need for physical contact and offer no advance warning of overhead or distant obstacles. Our project addresses these limitations through the development of *SightShift*, a smart cane that uses ultrasonic sensors and a microcontroller to detect obstacles and provide timely feedback through vibration, sound, and light signals.

The system integrates a buzzer, LED, vibration motor, and optional GPS module to improve user safety and independence. It is lightweight, affordable, and designed to detect objects in the range of 2–4 meters. By applying embedded system principles and leveraging Arduino programming, we've built an effective assistive tool tailored for real-world navigation.

Architecture of Arduino Uno

The **Arduino Uno** is a microcontroller development board based on the **ATmega328P** microcontroller. It features a simple and open-source hardware architecture that makes it ideal for beginners and embedded system developers. The board includes **14 digital input/output pins** (of which 6 can be used for PWM output), **6 analog input pins**, a **16 MHz quartz crystal oscillator**, a **USB connection** for programming and power, a **DC power jack**, and an **ICSP header** for direct programming of the microcontroller. The ATmega328P has a **32 KB flash memory** for code storage, **2 KB SRAM**, and **1 KB EEPROM**. It communicates with sensors and actuators using standard digital and analog pins, and it can interface with other devices via **UART, SPI, and I²C** protocols. Its simplicity, expandability, and the availability of a user-friendly IDE make the Arduino Uno a popular choice for a wide range of electronic projects.



Objectives of the Project

- Study and apply microcontroller-based sensing and alert systems.
- Use ultrasonic range finding for short-distance obstacle detection.
- Define system requirements and design specifications based on existing literature.
- Develop a functional block diagram for the smart cane system.
- Measure and alert obstacle distance using sensor feedback.
- Interface and integrate components like ultrasonic sensors, Arduino, buzzer, LED, and vibration motor.
- Test system performance under real-world use cases.

Methodology

- A **functional block diagram** was designed based on the proposed features and user needs.
- **Hardware components** were selected and assembled, including sensors, power supply, and feedback units.
- **Arduino Uno** was chosen as the microcontroller for ease of programming and prototyping.
- The **HC-SR04 ultrasonic sensor** was implemented to detect obstacles and calculate distance using time-of-flight principles.
- **Embedded C code** was developed and uploaded using the Arduino IDE.
- Each module (sensor, output devices) was tested individually and then integrated.
- **Sensor logic:** The ultrasonic sensor sends out a pulse, receives the reflected wave, and calculates the distance.
- **Output control:** Based on the calculated distance, the Arduino activates the buzzer, LED, and vibration motor to alert the user.

Literature Review

Assistive technologies for visually impaired individuals have evolved significantly over the past few decades. While traditional white canes provide tactile feedback and help users detect nearby obstacles, they are limited in range and offer no warning for overhead or distant objects. To address these limitations, researchers have developed various **Electronic Travel Aids (ETAs)** using sensors, microcontrollers, and feedback systems to enhance mobility and safety.

A majority of these systems use **ultrasonic sensors** for obstacle detection due to their affordability, effectiveness, and immunity to ambient light interference. While these features offer a more comprehensive navigation experience, they significantly increase cost, size, and complexity—making them less accessible to the average user, especially in developing regions.

Our project, *SightShift*, is inspired by the fundamental concept behind these sophisticated systems but is intentionally simplified for broader accessibility. Instead of relying on complex modules, we use a basic **Arduino Uno**, **HC-SR04 ultrasonic sensor**, and **feedback components** like a buzzer, vibration motor, and LED. The cane provides alerts when an object is detected within a range of approximately 2 to 4 meters, ensuring that users receive timely notifications about obstacles in their path.

Unlike systems that require programming destinations, syncing with mobile apps, or handling voice input/output, *SightShift* focuses solely on **real-time obstacle detection and immediate user feedback**. This makes it ideal for individuals who need a **straightforward, reliable, and low-maintenance** mobility aid.

Literature from earlier studies supports the effectiveness of ultrasonic sensors in such applications, particularly in detecting static obstacles, steps, or walls. Some prior research also explored water detection and dark area sensing using additional sensors, but these are not included in our design due to the project's goal of keeping the cane **minimal and budget-friendly**.

```
#include <Wire.h> // Optional: not needed unless using I2C devices (safe to keep or remove)

#define trigPin 9

#define echoPin 10

#define buzzerPin 8

#define vibMotorPin 7

#define ledPin 6

void setup() {

    pinMode(trigPin, OUTPUT);

    pinMode(echoPin, INPUT);

    pinMode(buzzerPin, OUTPUT);

    pinMode(vibMotorPin, OUTPUT);

    pinMode(ledPin, OUTPUT);

    Serial.begin(9600);

}

void loop() {

    // Trigger the ultrasonic sensor

    digitalWrite(trigPin, LOW);

    delayMicroseconds(2);

    digitalWrite(trigPin, HIGH);

    delayMicroseconds(10);

    digitalWrite(trigPin, LOW);

    // Read the echo pin
```

Smart Cane

```
long duration = pulseIn(echoPin, HIGH); // Correct function

float distance = duration * 0.0344 / 2; // Accurate distance in cm

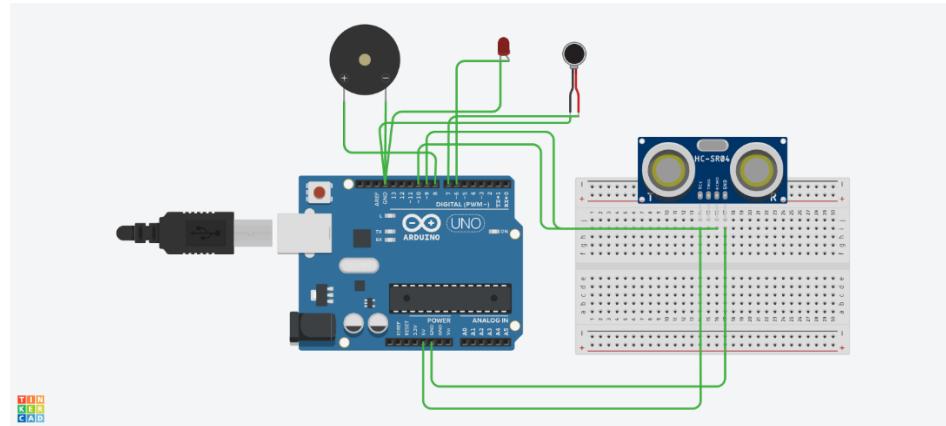
// Display distance
Serial.print("Distance: ");
Serial.print(distance);
Serial.println(" cm");

// Feedback if object is near
if (distance < 50) {
    digitalWrite(buzzerPin, HIGH); // Audio feedback
    digitalWrite(vibMotorPin, HIGH); // Tactile feedback
    digitalWrite(ledPin, HIGH); // Visual feedback
} else {
    digitalWrite(buzzerPin, LOW);
    digitalWrite(vibMotorPin, LOW);
    digitalWrite(ledPin, LOW);
}

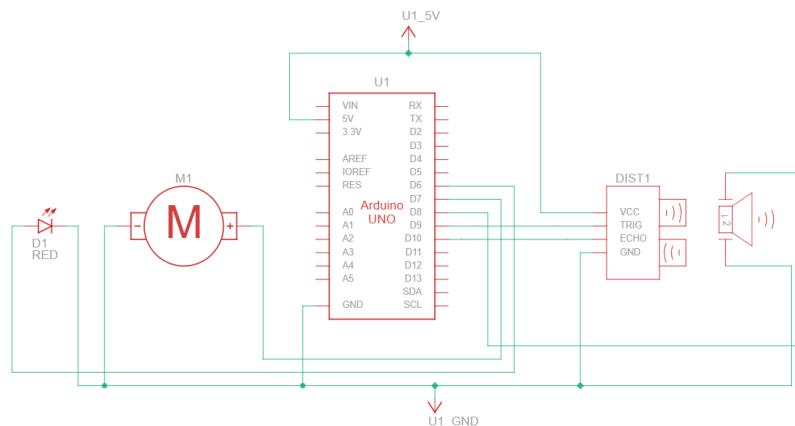
delay(500); // Delay between readings
}
```

In summary, while advanced assistive systems continue to push the boundaries of smart mobility, our project occupies a niche that emphasizes **functionality, simplicity, and affordability**—making it more viable for quick implementation, real-world testing, and adaptation by local communities or NGOs supporting visually impaired individuals.

Circuit Diagram of the Proposed System



Block Diagram of the Proposed System



The **circuit layout** and the **Block layout** for our proposed *SightShift Smart Cane* is shown in Figure 1. The system is centered around an **Arduino Uno R3 microcontroller**, interfaced with an **ultrasonic distance sensor (HC-SR04)**, **buzzer**, **LED**, and a **vibration motor**. The components are arranged on a breadboard and powered through the Arduino's 5V output, enabling a compact and easily programmable setup.

The core sensing element is the **ultrasonic sensor**, which emits high-frequency sound waves and listens for their reflection from nearby obstacles. The **Trig** and **Echo** pins of the sensor are connected to digital pins 9 and 10 of the Arduino, respectively. The sensor continuously measures the distance of objects in front of the user, with a reliable range of up to 400 cm.

When an object is detected within the **threshold distance of 50 cm**, the Arduino processes the sensor's signal and activates the **output alert system**:

- **Buzzer (Pin 8)**: Provides audio feedback
- **Vibration Motor (Pin 7)**: Provides tactile feedback
- **LED (Pin 6)**: Provides visual indication

The system was programmed using the **Arduino IDE** in **Embedded C**, and each component was individually tested before full integration. Once the ultrasonic sensor detects an object within range, the microcontroller instantly triggers all three alert mechanisms, helping the user avoid obstacles during indoor or outdoor movement.

In summary, the proposed system offers a basic yet effective obstacle detection solution. With its **lightweight construction, low power consumption, and straightforward usability**, it serves as a practical assistive tool for visually impaired users.

Identified User Requirements

The design and development of the *SightShift Smart Cane* were guided by specific user and functional requirements, particularly focusing on the needs of visually impaired individuals. The identified requirements for our system are:

- The **microcontroller (Arduino Uno)** should be capable of receiving data from the ultrasonic sensor in real time.
- The **ultrasonic sensor** must accurately measure the distance between the user and nearby obstacles.
- The system must provide **immediate feedback** when an obstacle is detected within a critical distance (less than 50 cm).
- The **feedback system** should include vibration, sound (buzzer), and visual (LED) alerts to support users with varying sensory preferences.
- The system should help users **make body movement decisions** based on obstacle proximity, allowing them to adjust their path accordingly.
- The entire system should be **compact, reliable, and low-cost** to ensure wide usability.

Hardware Requirements

For the implementation of the SightShift system, the following components were used:

- **Arduino Uno R3 Microcontroller** – For controlling the system and processing sensor data.
- **HC-SR04 Ultrasonic Sensor** – For detecting obstacles and measuring distance.
- **Buzzer** – For providing audio alerts to the user.
- **Vibration Motor** – For tactile feedback.
- **LED** – For visual indication of nearby obstacles.
- **Breadboard and Jumper Wires** – For assembling the circuit.
- **Power Supply** – USB or battery pack to power the Arduino.

Note: While LCDs and push buttons are used in some smart cane designs, they were intentionally omitted here to keep the device simple and focused on essential feedback systems.

Software Requirements

- **Arduino IDE** – For writing, compiling, and uploading code to the Arduino.
- **Embedded C** – As the primary programming language used for system logic.

Note: Other tools like Proteus or Willar were not required due to the basic nature of our project. However, they could be useful for future simulations or more complex system designs.

Applications

The SightShift Smart Cane can be adapted and applied in various domains, such as:

- **Assisting Visually Impaired Individuals** – Provides reliable real-time obstacle detection for safer navigation.
- **Obstacle Distance Measurement** – Useful in any context where physical distance to objects needs to be known.
- **Surveying and Architecture** – Adapted forms of this sensor system can be used for spatial measurements.
- **Obstacle Warning Systems** – Similar technology is used in basic security and navigation systems.
- **Automotive Parking Assistance** – HC-SR04 modules are widely used in reverse parking sensors.
- **Robotics and Terrain Monitoring** – Mobile robots can use similar designs to detect and avoid obstacles.

Results and Discussion

The initial electrical circuit for the SightShift Smart Cane was assembled and tested on a **breadboard**. Once the design was confirmed to function correctly—accurately detecting nearby obstacles and triggering output feedback—the circuit was prepared for more permanent implementation.

The system was programmed using **Embedded C** through the Arduino IDE. A **trigger signal** was sent from the Arduino to the HC-SR04 ultrasonic sensor. Upon detecting an obstacle within a range of approximately **2 to 4 meters**, the sensor returned an **echo signal**, which the microcontroller used to calculate distance based on **time-of-flight (TOF)**. If the distance was less than the threshold of **50 cm**, the microcontroller activated three feedback mechanisms:

- A **buzzer** provided an audio alert.
- An **LED** lit up to indicate the warning visually.
- A **vibration motor** activated to deliver tactile feedback.

These components were tested under various conditions by placing obstacles like walls, chairs, and cardboard boxes at different distances. The system responded consistently, with the output signals being triggered only when an obstacle was within the programmed range.

The final result demonstrated reliable detection of objects and timely alerts. The use of an ultrasonic sensor ensured consistent readings unaffected by lighting conditions. The feedback mechanisms were **responsive**, and the **triplicate alert system** (sound, light, and vibration) ensured that users with varying sensory preferences could still receive obstacle warnings.

CONCLUSION: -

The design and implementation of the *SightShift Smart Cane* successfully addressed the need for a **basic, low-cost, and effective navigation aid** for visually impaired individuals. The system reliably detects obstacles within a **2–4 meter range**, providing immediate and intuitive feedback using a **buzzer, LED, and vibration motor**.

This project proves that even a simple configuration using commonly available components like an Arduino Uno and HC-SR04 sensor can greatly assist users in daily navigation. The device is **lightweight, portable, and easy to use**, making it suitable for real-world deployment and testing.

Although our current version is limited to obstacle detection and does not include features like water or pit sensing, it forms a strong foundation for future expansion. Enhancements such as **directional feedback, adjustable distance thresholds, or rechargeable battery integration** could improve its functionality further while maintaining its simplicity and affordability.

In conclusion, *SightShift* serves as a stepping stone toward empowering visually impaired individuals with accessible technology that enhances safety, confidence, and independence in both indoor and outdoor environments.