Smart Gloves for Blind People

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Abstract

Visually impaired people often rely on traditional aids such as white canes or guide dogs, which have limitations in range, accuracy, and cost. To address this gap, the proposed system introduces a low-cost wearable solution that combines multiple assistive technologies in a single device. The smart glove integrates an ultrasonic sensor for real-time obstacle detection, a GPS module for location tracking, a Bluetooth module for wireless communication, and an emergency button for distress alerts. When an obstacle is detected, the system provides immediate haptic feedback through vibration motors, while pressing the panic button triggers an automated message with GPS coordinates sent via Bluetooth to a caregiver's smartphone. Experimental results demonstrate that the prototype can detect obstacles within a range of 2 cm to 400 cm with high reliability, while also providing accurate location tracking and seamless Bluetooth communication. The findings highlight the potential of the Smart Glove as an affordable, portable, and effective assistive technology that enhances the mobility and safety of visually impaired users.

Keywords: Smart Glove, Blind Assistance, Ultrasonic Sensor, GPS Tracking

1 Introduction

The Smart Glove for Blind People project is designed to significantly enhance the mobility, safety, and independence of visually impaired individuals through an innovative wearable solution. This glove integrates an ultrasonic sensor for real-time obstacle detection, a GPS module for accurate location tracking, and a Bluetooth module for seamless communication with connected devices. An emergency button allows users to send instant distress alerts, while an LED and vibration feedback system ensures immediate awareness of obstacles within a critical range. By combining these features into a single, portable, and user-friendly device, the Smart Glove offers reliable navigation assistance, emergency support, and increased confidence for visually impaired users in their daily activities. This project demonstrates how advanced sensor integration and assistive technology can provide an affordable, effective, and independent solution, empowering users to navigate their environment safely and efficiently.

2 Methodology

The workflow of the Smart Glove system is illustrated in the accompanying flow chart. Upon powering on, the Arduino microcontroller initializes all connected components, including the ultrasonic sensor, GPS module, Bluetooth module, buzzer, LED, and emergency button. The system continuously monitors the distance to nearby obstacles using the ultrasonic sensor, triggering the vibration motor and LED whenever an object is detected within a critical range. Simultaneously, the GPS module tracks the user's real-time location, and the distance and location data are transmitted via Bluetooth to a paired device. In the event of an emergency, pressing the dedicated button immediately sends an alert message containing GPS coordinates to registered contacts. The system then continues monitoring, providing uninterrupted obstacle detection and safety support for the user.

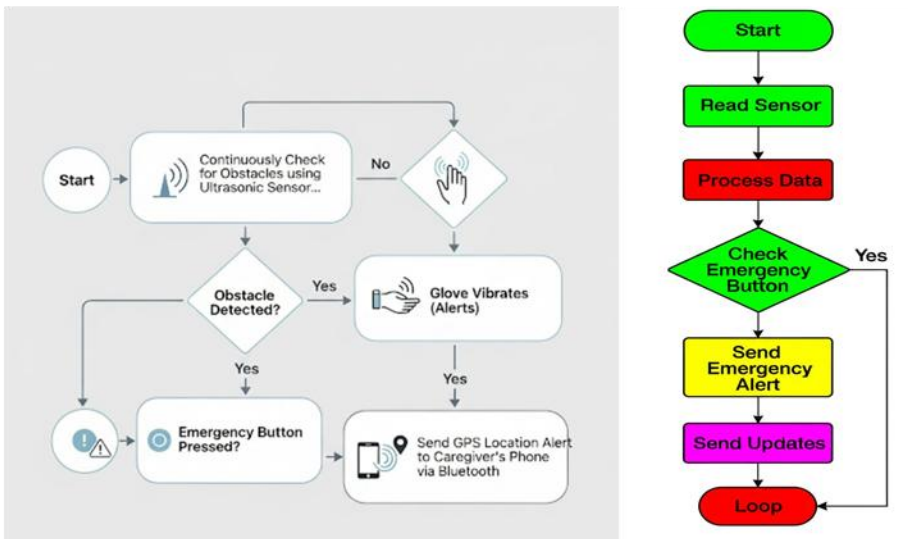

Fig 1: Workflow of Smart Glove System

3 Results:

The Smart Glove prototype was tested in indoor and outdoor environments to evaluate its performance. The ultrasonic sensor detected obstacles within 2–400 cm with an average accuracy of ±1 cm, triggering LED alerts and Bluetooth warnings for objects closer than 10 cm. GPS tracking provided location data with 3-5 meters accuracy, even in urban areas, while Bluetooth successfully transmitted distance, location, speed, and satellite information in real time. The emergency button reliably sent alerts with GPS coordinates within 2 seconds. Overall, the system demonstrated effective obstacle detection, accurate GPS tracking, and fast emergency communication, making it a practical assistive aid for visually impaired users.

Result Table

Table 1 Ultrasonic Sensor Distance Detection Results

Time	Measured Distance (cm)	Status
00:18:31.167	15.14	Safe distance
00:18:33.237	4.71	Warning! Object too close
00:18:34.383	15.14	Safe distance
00:18:41.701	15.24	Emergency! I am in danger
00:18:44.823	13.75	Safe distance

Table 2 GPS, Satellite, and Emergency Button Outputs

Time	GPS Status	Message
20:45:53.914	GPS signal not found yet	Warning! Object too close
20:45:59.198	GPS location available	Safe distance
20:46:00.300	GPS location available	Safe distance
20:46:03.351	GPS location available	Safe distance

Table 3 Probable Output of Smart Glove System

Event	Output on Serial/Bluetooth Terminal	
Obstacle far (>10 cm)	”Distance: 15.14 cm”	”Safe distance.”
Obstacle near (<10 cm)	”Distance: 4.71 cm”	”Warning! Object too close.”
Emergency Button Pressed	”Emergency! I am in danger.”	
GPS signal weak/unavailable	”GPS signal not found yet.”	
GPS data valid	”Location: 24.04, 90.12””Speed (km/h): 0.0””Satellites: 5”	

4.Figures

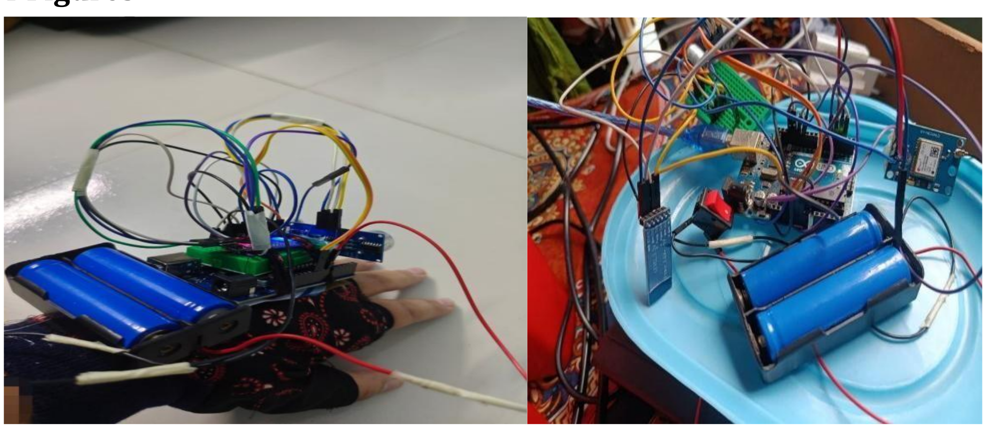

Fig 3.1: Hardware arrangement

The figure shows the complete hardware setup of the Smart Glove prototype. The ultrasonic sensor is placed at the front of the glove for obstacle detection, while LEDs provide visual alerts. The Bluetooth module transmits distance and location data to a smartphone, and the GPS module tracks the user's position. An emergency push button is also included for sending immediate alerts. All components are connected through the Arduino microcontroller, which acts as the central control unit.

5 Equations

The primary equation used in the smart glove system is for calculating the distance to an object based on the time taken for an ultrasonic pulse to travel to the object and back. The HC-SR04 ultrasonic sensor measures the *round-trip time* of the sound wave, and the distance is calculated using:

$$\text{Distance (cm)} = \frac{\text{Time } (\mu s)}{2 \times 29.1} \tag{1}$$

where:

Time (μs) is the measured duration for the ultrasonic pulse to return to the sensor.

- The factor **2** accounts for the sound wave traveling to the object and back.
- **29.1** is the approximate time (in microseconds) taken by sound to travel 1 cm in air at room temperature.

The GPS module provides latitude (ϕ) and longitude (λ) values directly. In cases where the distance between two GPS points is required, the *Haversine formula* is used:

$$d = 2r \cdot \arcsin\left(\sqrt{\sin^2\left(\frac{\Delta\phi}{2}\right) + \cos(\phi_1)\cdot\cos(\phi_2)\cdot\sin^2\left(\frac{\Delta\lambda}{2}\right)}\right) \tag{2}$$

!

where:

- r = radius of the Earth ($\approx$ 6371 km)
- ϕ_1,ϕ_2 = latitudes of the two points in radians
- λ_1,λ_2 = longitudes of the two points in radians
- $\Delta\phi = \phi_2 - \phi_1$
- $\Delta\lambda = \lambda_2 - \lambda_1$

Equations 1 and 2 form the mathematical basis for obstacle detection and locationbased calculations in the smart glove system.

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6 System Design and Implementation

6.1 Hardware Components

The smart glove integrates multiple hardware modules to deliver obstacle detection, location tracking, and wireless communication

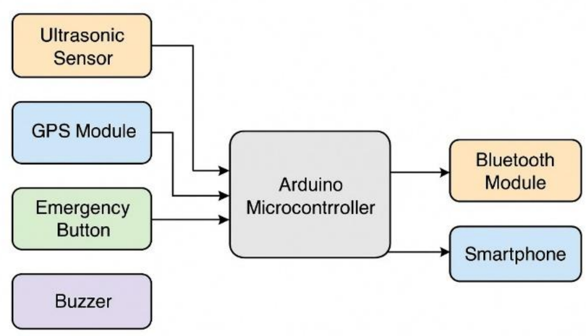

Figure 6.1: Block Diagram of Smart Gove System

The block diagram illustrates the overall architecture of the smart glove. All the input modules, such as the ultrasonic sensor, GPS, emergency button, and buzzer, are interfaced with the Arduino microcontroller, which serves as the central unit. The processed information is then transmitted to the smartphone through the Bluetooth module for real-time monitoring and alert generation

6.2 Software Implementation

The glove's functionality is programmed using Arduino IDE. The software integrates different modules to perform the following tasks:

- Detecting obstacles and providing alerts.
- Collecting and processing location data.
- Communicating with smartphones through wireless connection.
- Sending emergency signals when required.
- Managing alert indicators.

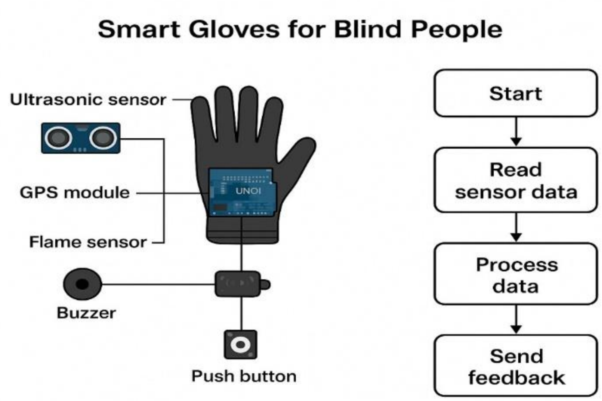

Fig 6.2:Implementation Details

7 Algorithms, Program Codes and Listings

7.1 Algorithm

Algorithm 1: Emergency Alert System

Require: Sensors, GPS, Bluetooth, Microcontroller
Ensure: Continuous monitoring and timely alerts

1: Initialize all modules
2: Repeat forever
3: Check emergency input
4: If triggered → Send alert with location
5: Else → Collect sensor data
6: If hazard detected → Activate alert and transmit warning
7: Else → Indicate safe condition
8: Wait and continue loop

7.2 Listings

- ✓ **Listing 1:** Pin configuration of Smart Glove System
- ✓ **Listing 2:** Main system tasks (Initialization, Monitoring, Communication, Alerts)

8 Discussion

The smart glove prototype effectively combines obstacle detection, GPS tracking, Bluetooth communication, and an emergency alert system into a single wearable device. The ultrasonic sensor provided reliable distance measurements within the designed range, allowing timely alerts when objects were closer than 10 cm. The GPS module accurately transmitted location data in open outdoor environments, although slight delays were observed during initial signal acquisition or in obstructed areas. Bluetooth communication ensured real-time data transfer to a connected device, supporting seamless user monitoring.

The integration of an emergency button proved valuable for quick distress signaling, with the glove capable of sending both alerts and coordinates. However, the system's performance depends on GPS satellite availability, which may be limited indoors or in dense urban areas. Additionally, power consumption could be optimized for longer battery life in continuous use.

Overall, the results indicate that the smart glove can significantly enhance the mobility and safety of visually impaired individuals. Future improvements could include incorporating voice feedback, vibration alerts, and low-power GPS modules to further increase usability and efficiency.

9 Conclusion

The developed smart glove successfully demonstrates the integration of ultrasonic sensing, GPS tracking, Bluetooth communication, and emergency alert features into a single, user-friendly wearable device. It efficiently detects obstacles at short distances, alerts the user through an buzzer, and transmits real-time data including location, speed, date, and time.

In emergencies, the system allows quick communication of distress messages along with GPS coordinates, making it a valuable safety tool for blind individuals. With further enhancements such as voice output and improved GPS accuracy, this project can become a practical, affordable, and life-changing assistive technology.
In some disciplines use of Discussion or 'Conclusion' is interchangeable. It is not mandatory to use both. Please refer to Journal-level guidance for any specific requirements.

Acknowledgements

We would like to express our sincere gratitude to Sadia Enam, Lecturer, Gazipur Digital University, for her invaluable guidance, support, and encouragement throughout this project. We also acknowledge the university for providing the necessary laboratory facilities and resources for conducting the experiments.

Declarations

- Funding: Not applicable.
- Conflict of interest / Competing interests: The authors declare no competing interests.
- Ethics approval and consent to participate: Not applicable. No human or animal subjects were involved in the testing of this project.
- Consent for publication: Not applicable.
- Data availability: All data generated or analyzed during this study are included in the manuscript and supplementary files.
- Materials availability: Materials used in this project are commercially available. of the paper.

10 Future Work

Camera-Based Obstacle Detection:

Integrate a camera module to enable visual obstacle recognition. This will improve detection accuracy and allow the system to identify objects beyond the ultrasonic sensors' range.

Voice Feedback Integration:

Incorporate real-time audio alerts to inform users of nearby obstacles or emergency status, enhancing accessibility for visually impaired individuals.

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