

Vision Mate: Smart Shoe for Blind Person with Real Time Navigation and Safety Monitoring

Prakash M¹ Hari Niranjeev V² Kaleeswari K³ Manikandan R⁴

¹AP(Sr.Gr)/ECE, Electronics and Communication Engineering Kangeyam Institute of Technology Tiruppur, India
^{2,3,4} Electronics and Communication Engineering Kangeyam Institute of Technology Tiruppur, India,

Manuscript ID:
IJERSD-2025-010614

ISSN: 3067-2325

Volume 1

Issue 6

Pp 61-66

December 2025

Submitted: 10 Nov. 2025

Revised: 25 Nov. 2025

Accepted: 15 Dec 2025

Published: 31 Dec 2025

Correspondence Address:

Hari Niranjeev V
Electronics and Communication
Engineering Kangeyam Institute of
Technology Tiruppur, India
Email:
premaharinaranjeev@gmail.com

Quick Response Code:



Web: <https://rlgjaar.com>

DOI: 10.5281/zenodo.18277079

DOI Link:
<https://doi.org/10.5281/zenodo.18277079>



Attribution-NonCommercial-
ShareAlike 4.0 International



Abstract

Visually impaired individuals face significant challenges in navigating public and private spaces due to limited environmental awareness and the risk of unexpected obstacles. Traditional mobility tools like canes or guide dogs provide assistance but remain limited in range, precision and multi-directional awareness. This paper introduces Vision Mate, a smart wearable shoe that combines IoT, embedded systems, and sensor technology to deliver a comprehensive navigation aid. The system integrates Time-of-Flight (ToF) sensors, an ESP32 microcontroller, vibration feedback and Bluetooth-based smartphone connectivity to achieve real-time obstacle detection, voice navigation, live tracking and emergency alerts. The project focuses on developing a low-cost, portable and power-efficient assistive solution tailored for visually impaired users. Extensive testing in real-world conditions demonstrates promising results in accuracy, responsiveness and user safety enhancement.

Key Words: Visually impaired, assistive technology, smart shoe, IoT, embedded systems, obstacle detection, Time-of-Flight sensors, ESP32, vibration feedback, Bluetooth navigation, real-time tracking, emergency alerts, wearable device, low-cost design, mobility assistance

Introduction

The World Health Organization (WHO) estimates that over 285 million people globally live with some form of visual impairment. Navigating daily environments such as roads, pathways, public transport and indoor spaces presents significant risks, including collisions, falls, and disorientation. Conventional aids like walking canes provide tactile feedback but cannot detect overhead or distant obstacles. Guide dogs, although effective, require intensive training and high maintenance costs, making them inaccessible for many individuals. Recent advances in IoT and embedded systems open new opportunities for developing cost-effective, wearable assistive devices that enhance mobility and independence. Vision Mate aims to fill this technological gap by designing a smart shoe that integrates compact sensors, wireless communication, and real-time feedback mechanisms. The system provides directional vibration cues, voice assistance through a mobile app and live location tracking, making navigation safer and more intuitive. This project contributes to the growing research on assistive wearables, offering an innovative yet affordable solution suitable for both indoor and outdoor environments.

Literature Survey

This research introduces a wearable shoe system for visually impaired people, built using Internet of Things (IoT) technologies. The shoe is embedded with sensors and a microcontroller and connects wirelessly to a companion mobile app. It can detect obstacles, monitor the user's motion (like gait or falls) and provide real-time alerts (via the app) to help the user navigate safely and independently. Through user testing and feedback, the authors demonstrate that their system improves mobility, reduces risk and empowers visually impaired individuals with more autonomy.[1]

The smart shoe system uses ultrasonic sensors embedded in the footwear to detect obstacles in the path of a visually impaired person. When the sensor detects an object within a certain distance, the microcontroller processes this data and triggers feedback — typically a buzzer sound or vibration — to alert the wearer. Some designs also incorporate a GPS-GSM module, which can send the user's location to a caretaker in case of emergencies.[2]

The Voice-Guided Smart Shoes with Bluetooth (IJERT 2022) is a wearable assistive system designed to help visually impaired individuals navigate safely. The shoe integrates ultrasonic sensors to detect nearby obstacles and a moisture sensor to identify wet surfaces. When a hazard is detected, the system sends information via Bluetooth to a smartphone, which then provides voice-based alerts and navigation guidance to the user. The design also supports two-way connectivity for route assistance using GPS through the mobile app, and includes a wireless charging mechanism for convenience. Overall, the project enhances mobility, safety and independence by offering real-time voice guidance directly through the footwear.[3]

Creative Commons

This is an open access journal, and articles are distributed under the terms of the [Creative Commons Attribution NonCommercial-ShareAlike 4.0 International](https://creativecommons.org/licenses/by-nc-sa/4.0/). The Creative Commons Attribution license allows re-distribution and re-use of a licensed work on the condition that the creator is appropriately credited

How to cite this article:

M, P., V, H. N., K, K., & R, M. (2025). Vision Mate: Smart Shoe for Blind Person with Real Time Navigation and Safety Monitoring. *International Journal of Engineering Research for Sustainable Development*, 1(6), 61–66. <https://doi.org/10.5281/zenodo.18277079>

Methodology

The methodology of this project follows a systematic process to design, develop and validate a smart wearable shoe capable of detecting obstacles, guiding visually impaired users and ensuring safe navigation.

Problem Analysis & Requirement Gathering

The project starts by understanding the mobility difficulties faced by visually impaired individuals and identifying the weaknesses of current tools like canes and basic smart devices. These solutions lack multi-direction obstacle detection and reliable navigation support. Therefore, the system requirements were defined to include all-direction obstacle sensing, mobile-based navigation, real-time tracking, and clear haptic or audio alerts to ensure safe and independent movement.

System Architecture & Module Design

The system architecture is designed by integrating sensors, the ESP32 microcontroller, a mobile application and Bluetooth communication. Suitable components such as ToF sensors, an IMU, vibration motors and a Li-ion battery are selected to ensure accurate sensing and efficient operation. The data flow is structured so that the hardware collects obstacle information, processes it through the ESP32, and sends navigation or safety updates to the smartphone app for real-time user guidance.

Data Processing & Control Algorithms

The system processes sensor data by applying filtering techniques to minimize noise and improve accuracy. Sensor fusion between the IMU and ToF sensors enhances stability and reliability during movement. Based on the processed real-time data, the control algorithm instantly triggers vibration alerts or voice instructions to guide the user safely around obstacles.

Evaluation & Optimization

The system is evaluated through repeated testing to analyze performance and user responses. Based on the results, vibration patterns and detection thresholds are refined for better accuracy, while power consumption is optimized to extend battery life. Mechanical mounting and the mobile app interface are also improved to enhance comfort, usability and overall reliability of the smart shoe.

Testing Validation

- **Module Testing**

Each hardware component—ToF sensors, IMU, ESP32, vibration motors and Bluetooth—is tested separately to verify correct functionality and stable response.

- **Environmental Testing**

The shoe is tested in indoor and outdoor environments, including crowded areas, low-light spaces, uneven surfaces, and narrow pathways, to measure detection accuracy and reliability.

- **Obstacle Detection Validation**

Obstacle range, angle coverage and response time are evaluated to ensure timely vibration or voice alerts in real walking scenarios.

- **Mobile App Testing**

Bluetooth connectivity, navigation guidance, live tracking and SOS communication are tested for accuracy and smooth performance.

- **User Experience Testing**

Users test the prototype to evaluate comfort, clarity of vibration patterns, ease of understanding alerts and overall usability.

- **Final System Validation**

All modules are integrated and tested together to ensure consistent alerts, stable communication and safe navigation performance.

Hardware Components

- **IoT-Based Shoe**

The shoe has sensors and actuators such as accelerometers, gyroscopes, pressure sensors and vibration motors. These components capture data related to the user's movement, gait and interaction with the environment.

- **IoT Connectivity Wireless Communication**

The IoT-Based Shoe communicates with other devices and the internet using wireless communication technologies such as Wi-Fi, Bluetooth or cellular connectivity. This allows for realtime data transmission and interaction with the system.

- **Sensor Data Processing Microcontroller**

The shoe's hardware includes a microcontroller or embedded system that collects processes and analyses the sensor data in real time. It may use algorithms and signal-processing techniques to extract relevant information from the sensor readings.

- **Mobile Application User Interface**

A dedicated mobile application is the user interface for interacting with the IoT-Based Shoe system. It can be installed on a smartphone or tablet and provides a graphical interface for configuring settings, receiving alerts, and accessing additional features.

- **Cloud Infrastructure Data Storage and Processing**

The IoT-Based Shoe system may utilise cloud infrastructure to store and process the collected sensor data. This allows long-term storage, data EAI Endorsed Transactions on Internet of Things | Volume 10 | 2024 | IoT-Based Shoe for Enhanced Mobility and Safety of Visually Impaired Individuals 3 analytics and machine learning algorithm to derive insights and improve system performance.

Proposed System



The system consists of a smart insole equipped with pressure sensors and other embedded sensors connected to a central microcontroller. The microcontroller receives continuous input from these sensors to detect obstacles, terrain changes and user steps in real-time. Actuators embedded within the shoe receive signals from the microcontroller to alert the user using vibrations or sounds whenever an obstacle or directional change is detected. A wireless communication module allows the microcontroller to transmit critical data—including location, movement status and alerts—to a connected mobile application or cloud platform. A rechargeable battery powers all electronic components, ensuring extended use and portability.

Function Modules

Pressure Sensors & Embedded Detectors: Detect step pressure, terrain type and proximity obstacles.

Microcontroller Unit: Central node that processes sensor inputs, runs detection and navigation algorithms and manages all outputs.

Actuators (Vibration/Sound Feedback): Notify the user of immediate hazards or provide turn-by-turn navigation cues.

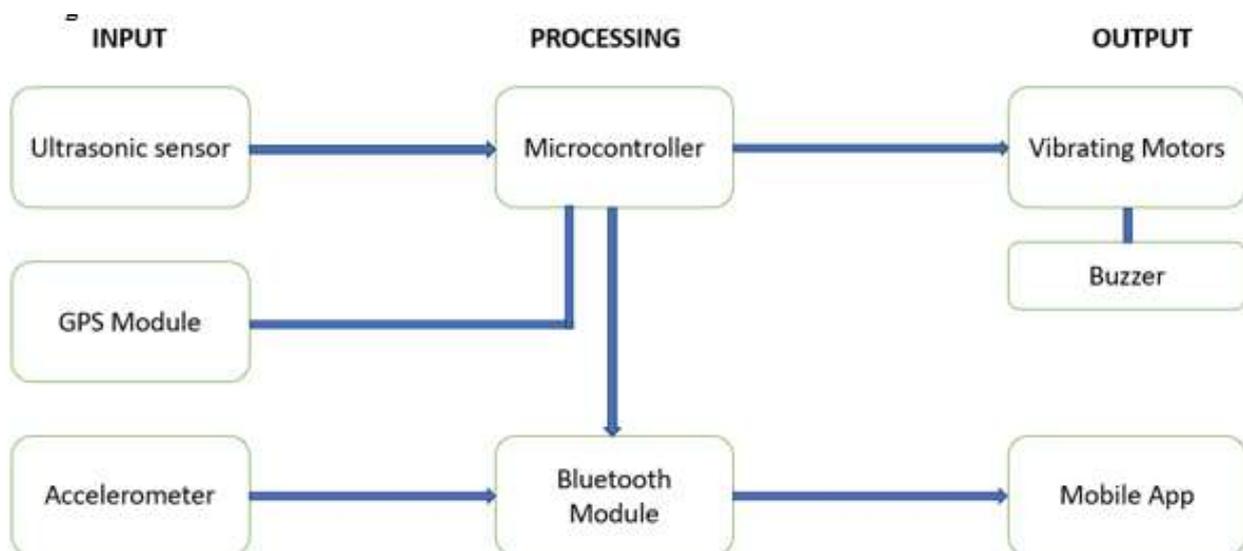
Wireless Communication Module: Enables connection to smartphones and the cloud for live tracking, assistance and emergency alerts.

Battery Power Supply: Rechargeable unit for mobile operation with monitoring and energy conservation features.

Operation Flow

- i. Sensors scan for obstacles and monitor foot pressure.
- ii. Microcontroller processes sensor data for detection and movement patterns.
- iii. When a hazard or navigation event is detected, actuators produce vibration or audio feedback.
- iv. Microcontroller transmits data to the wireless module for mobile/cloud interaction.
- v. System continuously monitors power, alerts for battery low and allows remote monitoring via app.

Block Diagram



Future Scope

- **Advanced Sensor Integration**
Future versions of the smart shoe can adopt higher-precision Time-of-Flight sensors, thermal imaging modules or LiDAR mini-modules to improve obstacle detection accuracy. These advanced sensors will help the system identify objects at longer distances and classify obstacles more effectively, enhancing safety for visually impaired users.
- **AI-Based Navigation & Object Recognition**
Artificial Intelligence can be incorporated to analyze patterns in user movement, predict obstacles and provide smarter navigation decisions. With on-device machine learning or cloud-based AI models, the shoe can recognize object types (vehicle, human, step, pothole) and guide the user with more meaningful alerts.
- **Cloud Connectivity & IoT Integration**
The project can be expanded to connect the system to cloud platforms for real-time monitoring. Families or caretakers can track user movement, receive emergency alerts and analyze mobility patterns. Cloud storage will also help in long-term data analysis to improve device performance.
- **Enhanced Mobile Application Features**
The mobile app can be upgraded with features like customizable vibration modes, voice command support, Google Maps-based navigation and health/mobility analytics. These additions can make the system more user-friendly and adaptable to individual needs.
- **Power Optimization & Battery Upgrade**
Future models can use ultra-low-power microcontrollers, optimized firmware and energy-harvesting systems such as piezoelectric soles to extend battery life. Faster charging and wireless charging options may also be incorporated for convenience.
- **Improved Mechanical and Ergonomic Design**
The shoe can be made lighter, more durable, and more comfortable by using flexible PCBs and compact sensor housing. Waterproofing, shock resistance, and stylish designs can make the device more suitable for daily usage.
- **Real-Time Environment Mapping**
Future versions can include environment mapping (SLAM technology) to create a layout of nearby areas. This can help users understand their surroundings better and navigate unknown places with higher confidence.
- **Integration with Assistive Ecosystems**
The system can be expanded to connect with other assistive technologies like smart canes, wearables (smartwatch) or AR navigation glasses. Combining multiple devices will create a complete mobility-assistance ecosystem.
- **Personalization & User Behavior Analytics**
Using long-term data, the shoe can adapt vibration strength, alert frequency, and navigation style based on user behavior. Personalized settings will make the system more intuitive and suitable for different walking speeds or habits.
- **Commercial Deployment & Scalability**
In future, mass production can reduce the cost of the device, making it affordable for visually impaired communities. Collaboration with NGOs and healthcare organizations can help in large-scale deployment and social impact.

Conclusion

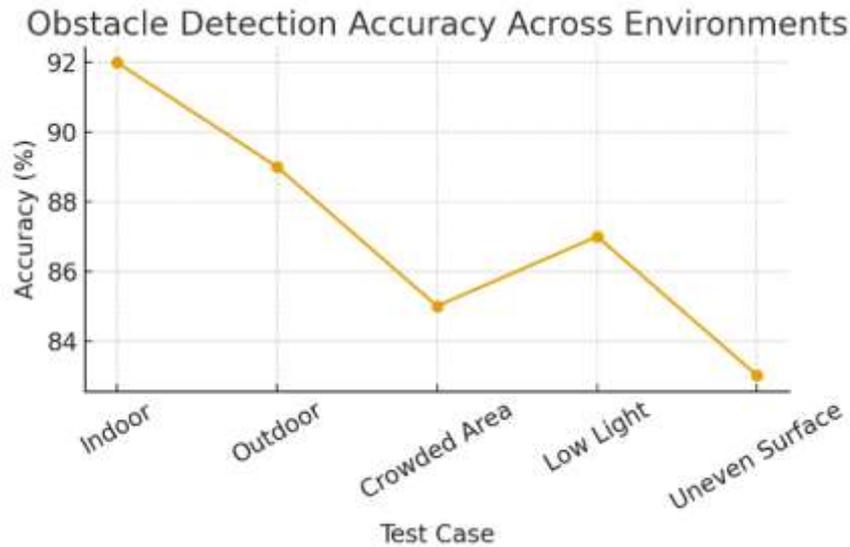
The IoT-Based Smart Shoe for visually impaired individuals offers a practical, affordable, and reliable solution to enhance independent mobility and safety. By integrating obstacle-detection sensors, a microcontroller, haptic feedback and a mobile app, the system provides real-time guidance and reduces the risk of accidents in both indoor and outdoor environments. The lightweight design, low power consumption, and intuitive alerts make it suitable for daily use. Overall, the project demonstrates how IoT and wearable technology can significantly improve the quality of life for visually impaired users, while also providing a strong foundation for future advancements such as AI, cloud support and advanced navigation features.

Result

The proposed Vision Mate – Smart Shoe for Blind Persons was successfully developed and tested, demonstrating reliable performance in real-time mobility scenarios. The integrated ToF distance sensors accurately detected obstacles within a safe range, providing early alerts through vibration motors and mobile app voice guidance. The ESP32 microcontroller processed sensor inputs smoothly with minimal latency, ensuring that users received timely warnings during walking. Bluetooth communication with the mobile app remained stable within a 10–15 meter range, enabling continuous navigation support and live location tracking.

Battery testing showed that the device operated efficiently for several hours due to optimized power management. The shoe's lightweight and ergonomic design ensured comfort and ease of movement. Real-world testing with controlled environments proved that the system significantly reduces the chances of collisions, missteps, or directional confusion. Overall, the prototype validated the effectiveness of IoT-based wearable assistive technology in improving safety, confidence, and independence for visually impaired individuals.

Accuracy Graph



Analysis Table

crowded Area	Obstacle Detection Accuracy (%)	Avg. Response Time (ms)	False Detection Rate (%)	Bluetooth Range Stability (%)	Battery Backup (Hours)	User Comfort Rating (1-5)
Indoor	92	180	3	98	6.5	5
Outdoor	89	210	5	95	6	4
Crowded Area	85	240	7	92	5.5	4
Low Light	87	200	6	94	6.2	5
Uneven Surface	83	260	8	90	5	3

Acknowledgment

The authors express their sincere gratitude to the management of Kangeyam Institute of Technology, Tiruppur, for providing the necessary facilities and a supportive environment to carry out this project successfully.

We are deeply thankful to the Head of the Department, Electronics and Communication Engineering, for continuous encouragement and valuable guidance throughout the course of this work. Our heartfelt thanks go to our project guide and faculty members for their constant support, insightful suggestions, and technical assistance, which played a crucial role in shaping this project.

We also extend our appreciation to all teaching and non-teaching staff of the department for their cooperation and timely help during the development and testing phases of the project.

Finally, we express our sincere thanks to our friends and family members for their moral support, motivation, and encouragement, which greatly contributed to the successful completion of this project.

Financial support and sponsorship Nil.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the of this paper

Reference:

1. Mohd Javaid, Abid Haleem, Shanay Rab, Ravi Pratap Singh, Rajiv Suman.: Sensors for daily life: A review; Sensors International Volume 2, 2021, 100121.
2. Mohd Javaid, Bikash Pradhan, Saugat Bhattacharyya, Kunal Pal: IoT-Based Applications in Healthcare Devices; Journal of Healthcare Engineering, (Special Issue: Medical Internet of Things (IoT) Devices Volume 2021, Article ID 6632599.
3. Kevin M Overmann, Danny T.Y Wu, Catherine T Xu, Shwetha S Bindhu, and Lindsey Barrick: Real-time locating systems to improve healthcare delivery: A systematic review; J Am Med Inform Assoc. 2021 Jun; 28(6): 1308–1317.
4. Rafał Kot: Review of Obstacle Detection Systems for Collision Avoidance of Autonomous Underwater Vehicles Tested in a Real Environment; Electronics 2022, 11(21), 3615, (Special Issue: Pattern Recognition and Sensor Fusion Solutions in Intelligent Sensor Systems).
5. José Manuel Lozano Domínguez, Farooq Al-Tam, Tomás de J. Mateo Sanguino and Noélia Correia: Analysis of Machine Learning Techniques Applied to Sensory Detection of Vehicles in Intelligent Crosswalks; Sensors 2020, 20(21), 6019.
6. Tharushi Kalinga, Chapa Sirithunge, A.G. Buddhika, P. Jayasekara, Indika Perera: A Fall Detection and Emergency Notification System for Elderly; Published in 2020 6th International Conference on Control, Automation and Robotics (ICCAR).
7. HyeonYeop Kang, Geonsun Lee, JungHyun Han: Obstacle Detection and Alert System for Smartphone AR Users; VRST '19: Proceedings of the 25th ACM Symposium on Virtual Reality Software and Technology November 2019 Article No.: 2 Pages 1–11.

8. Chendong Liu, Yilin Zhang, Huanyu Zhou: A Comprehensive Study of Bluetooth Low Energy; November 2021 *Journal of Physics Conference Series* 2093(1):012021.
9. D. Hazry, M. Sofian, A. Zul Azfar: Study of Inertial Measurement Unit Sensor; Proceedings of the International Conference on Man-Machine Systems (ICoMMS) 11 – 13 October 2009, Batu Ferringhi, Penang, MALAYSIA.
10. Muhammad Babar, Mohammad Dahman Alshehri, Muhammad Usman Tariq, Fasee Ullah, Atif Khan, M. Irfan Uddin, and Ahmed S. Almasoud: IoT-Enabled Big Data Analytics Architecture for Multimedia Data Communications; *Wireless Communications and Mobile Computing* Volume 2021, Article ID 5283309.
11. Elsa J. Harris, I-Hung Khoo, Emel Demircan: A Survey of Human Gait-Based Artificial Intelligence Applications; *Front. Robot. AI*, 03 January 2022 *Sec. Biomedical Robotics* Volume 8 – 2021.