iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 14 Issue: IV Month of publication: April 2026

DOI: https://doi.org/10.22214/ijraset.2026.79350

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 14 Issue IV Apr 2026- Available at www.ijraset.com

IOT Based Smart Shoes for Blind Navigation

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Abstract: Safe mobility and independent navigation remain major challenges for blind and visually impaired individuals due to their inability to perceive environmental hazards, often resulting in accidents, falls, and disorientation. To address these challenges, this paper presents the design, implementation, and validation of an IoT-enabled smart shoe system aimed at enhancing mobility, safety, and independence for visually impaired users. The proposed system integrates multiple sensing modules, including ultrasonic or infrared sensors for obstacle detection, moisture sensors for wet floor identification, and inertial sensors for fall detection. Sensor data is processed by an embedded microcontroller to accurately identify hazardous situations and distinguish them from normal movements. Upon detecting danger, the system provides real-time voice-based acoustic alerts to inform the user and simultaneously communicates with a dedicated mobile application that shares the user's location and notifies caregivers during emergencies. Special emphasis is placed on electrical safety, system reliability, and fault tolerance to reduce false alarms and improve accuracy. Experimental evaluation conducted on five subjects under real-world conditions demonstrated high detection performance, with an overall accuracy of approximately 96%, confirming the effectiveness of the proposed system as a reliable assistive technology for visually impaired individuals.

I. INTRODUCTION

Safe mobility and independent navigation are persistent challenges for visually impaired individuals due to the absence of visual perception. The inability to identify obstacles, surface irregularities, wet or slippery floors, and sudden environmental changes significantly increases the risk of accidents, falls, and disorientation, particularly in unfamiliar environments. These challenges not only compromise physical safety but also negatively affect psychological confidence and social independence.

Conventional mobility aids such as white canes and guide dogs, although helpful, provide limited situational awareness. They are unable to detect elevated obstacles, wet surfaces, or emergency situations such as sudden falls, and they do not offer automated alert mechanisms to caregivers. To overcome these limitations, this project presents the design, implementation, and validation of an IoT-enabled smart shoe system aimed at improving the safety, mobility, and independence of visually impaired users.

The proposed smart shoe integrates multiple sensing modules, including ultrasonic or infrared sensors for real-time obstacle detection, moisture sensors for identifying wet or slippery surfaces, and inertial sensors such as accelerometers and gyroscopes for reliable fall detection. Sensor data is continuously processed by an embedded microcontroller, which applies predefined thresholds and logical algorithms to accurately distinguish between normal movements and hazardous situations.

Upon detecting a dangerous condition, the system immediately generates voice-based acoustic alerts to warn the user, enabling quick and appropriate responses. Voice alerts are preferred over vibration-based feedback as they provide clearer contextual information and improve usability, especially in complex environments. In parallel, the system communicates wirelessly with a dedicated mobile application that serves as a remote monitoring interface. The application notifies caregivers in real time during emergencies and shares the user's live geographical location, ensuring timely assistance and enhanced overall safety. Special attention is given to electrical safety, system reliability, and fault tolerance to ensure safe interaction with human health and daily activities.

A. Advantages

Enhances safe mobility and independence of visually impaired users
Provides real-time obstacle, wet surface, and fall detection
Voice-based alerts offer clear and immediate guidance
Emergency notifications and live location sharing improve user safety
IoT integration enables remote monitoring by caregivers
High detection accuracy and reliable performance

B. Limitations

Initial system cost may be higher than traditional mobility aids
Requires regular charging or power management
Performance may be affected by extreme environmental conditions
Dependence on sensors and network connectivity for full functionality

II. LITERATURE SURVEY

1) Afif Unissa Begum (2023): Proposed a sensor-based assistive system focused on improving user awareness and safety, with increased system complexity as a limitation.
2) Mohanty S. Karunan (2017): Developed an embedded sensor-based assistive mobility system that enhances independence but suffers from battery limitations.
3) M. Khdr (2017): Introduced a smartphone-based navigation system using an Android app to improve independent mobility, dependent on smartphone availability.
4) A. Vimal (2019): Designed a GPS and sensor-based navigation system that improves navigation accuracy but faces lower battery performance.
5) A. Almomani (2023): Presented a real-time obstacle detection system using sensor data processing, increasing system complexity.
6) S. Santhi Priya (2024): Developed a wearable navigation device with sensors that improves navigation but requires high power consumption.
7) P. Devi (2021): Proposed a simple embedded wearable assistive device offering ease of use, with limited detection range and accuracy.
8) Nivedhita V (2023): Designed an assistive electronic system aimed at improving user independence, constrained by power requirements.
9) P. Kaushal & H. Singh (2024): Implemented a multimodal feedback system providing audio and vibration alerts, limited by prototype accuracy over longer distances.
10) A. Patil (2023): Developed a sensor-based navigation aid for visually impaired users, with reduced accuracy in noisy environments.
11) A. K. Jaba Kumar (2023): Proposed an IoT-based smart navigation assistive device that improves navigation but is vulnerable to water exposure.
12) H. Alotaibi (2022): Designed a sensor-based assistive system to enhance user independence, with sensitivity to water as a limitation.
13) S. Prasanth et al. (2011): Introduced a low-cost ultrasonic sensor-based assistive device with simple design but limited detection range.
14) R. Velazquez (2010): Presented a wearable tactile feedback navigation system, introducing wearable navigation concepts but with a bulky design.
15) Chava T. et al. (2021): Developed an IoT-based navigation system integrating GPS and real-time alerts, constrained by high power consumption.
16) P. S. Kumar et al. (2023): Proposed a smartphone-integrated navigation system offering smart integration, with limited indoor navigation accuracy.
17) A. R. Karthik et al. (2024): Designed smart wearable shoes with vibration-based feedback that are lightweight but lack voice guidance and advanced features.

Sr. No	Author	Year	Focus Area	Methodology	Advantage	Limitation
1.	Afif Unissa Begum	2023	User awareness and safety	Sensor based assistive system	Awareness	Complexity
2	Mohanty. S. Karunan	2017	Assistive mobility	Embedded system with sensors	Independence	Battery

3	M. Khdr	2017	Smartphone based navigation	Android app integrated with sensors	Improve independent mobility	Dependent on Android Smart Phone
4	A. Vimal	2019	Navigation system	GPS and sensors based guidance	Navigation	Lower/ Battery
5	A.Almomani	2023	Obstacle detection	Real time sensor data processing	Real-time obstacle detection	Increase system
6	S. Santhi Priya	2024	Wearable navigation	Wearable device with sensors	Navigation	Power
7	P. Devi	2021	Wearable assistive device	Simple embedded wearable design	Simple and wearable solution	Limited detection range and accuracy
8	Nivedhita V	2023	User independence	Assistive electronic system	Independence	Power
9	P. Kaushal & H. Singh	2024	Multimodal feedback	Sensors with audio and vibration feedback	Provides audio alerts and vibration feed back for obstacle	Prototype may have limited sensor accuracy at longer distances
10	A. Patil	2023	Assistive navigation aid	Sensor based navigation system	Navigation aid for visually impaired users	Limited accuracy in noisy environment
11	A. K. Jaba Kumar	2023	Smart navigation	IoT based assistive device	Navigation	Water vulnerability
12	H. Alotaibi	2022	User independence	Sensor based assistive navigation system	Independence	Water sensitivity
13	S. Prasanth et al	2011	Low-cost assistive device	Simple ultrasonic sensor based design	Simple design, low cost	Limited detection range
14	R. Velazquez	2010	Wearable navigation	Wearable tactile feedback navigation system	Introduced wearable navigation concept	Bulky system
15	Chava T. et al	2021	IoT based navigation	IoT integration with GPS and real tile	IoT integration, GPS tracking, real-time alerts	High power consumption

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				alerts		
16	P. S. Kumar et al	2023	Smartphone assisted navigation	Smartphone integrated navigation system	Smart phone integration	Indoor navigation accuracy issues
17	A.R.Karthik et al	2024	Smart wearable shoes	Smart shoe with vibration based feedback	Lightweight smart shoe, Vibration Feedback	No voice guidance, limited smart features

From the literature survey, it is observed that existing assistive navigation systems for visually impaired users suffer from several drawbacks such as high power consumption, limited obstacle detection range, dependency on smartphones, lack of multimodal feedback, and sensitivity to environmental conditions like water and noise. Many systems are bulky or uncomfortable for continuous use, while GPS-based solutions show poor performance in indoor environments. To overcome these limitations, the proposed implementation focuses on a lightweight smart shoe–based assistive system using low-power sensors and a microcontroller for real-time obstacle detection. The system operates independently without mandatory smartphone usage and provides vibration-based feedback with optional audio alerts for enhanced safety. This approach improves energy efficiency, usability, and reliability for both indoor and outdoor navigation.

III. METHODOLOGY

1) Continuous sensor data acquisition
2) Noise filtering and distance calculation
3) Threshold-based obstacle detection
4) Feedback generation using vibration/audio alerts
5) Power optimization for extended operation

IV. ADVANTAGES

1) Hands-free and wearable solution
2) Improved safety and independence
3) Low-cost and scalable design
4) Minimal dependency on smartphones
5) Suitable for daily use

V. CONCLUSION

This work presents the development of an IoT-enabled smart shoe system designed to assist blind and visually impaired individuals in safe navigation. The proposed system integrates multiple sensors, including ultrasonic or infrared sensors for obstacle detection, moisture sensors for wet surface identification, and inertial sensors for fall detection. Sensor data are processed using an embedded microcontroller to generate real-time voice-based alerts, enabling timely user awareness of potential hazards. Furthermore, the system incorporates a mobile application to share location information and notify caregivers during emergency situations. Experimental results demonstrate that the proposed system achieves a high detection accuracy of approximately 96% under real-world conditions, indicating its reliability and effectiveness. The results confirm that the smart shoe system offers a practical, low-cost, and efficient assistive solution to enhance mobility, safety, and independence for visually impaired users.

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