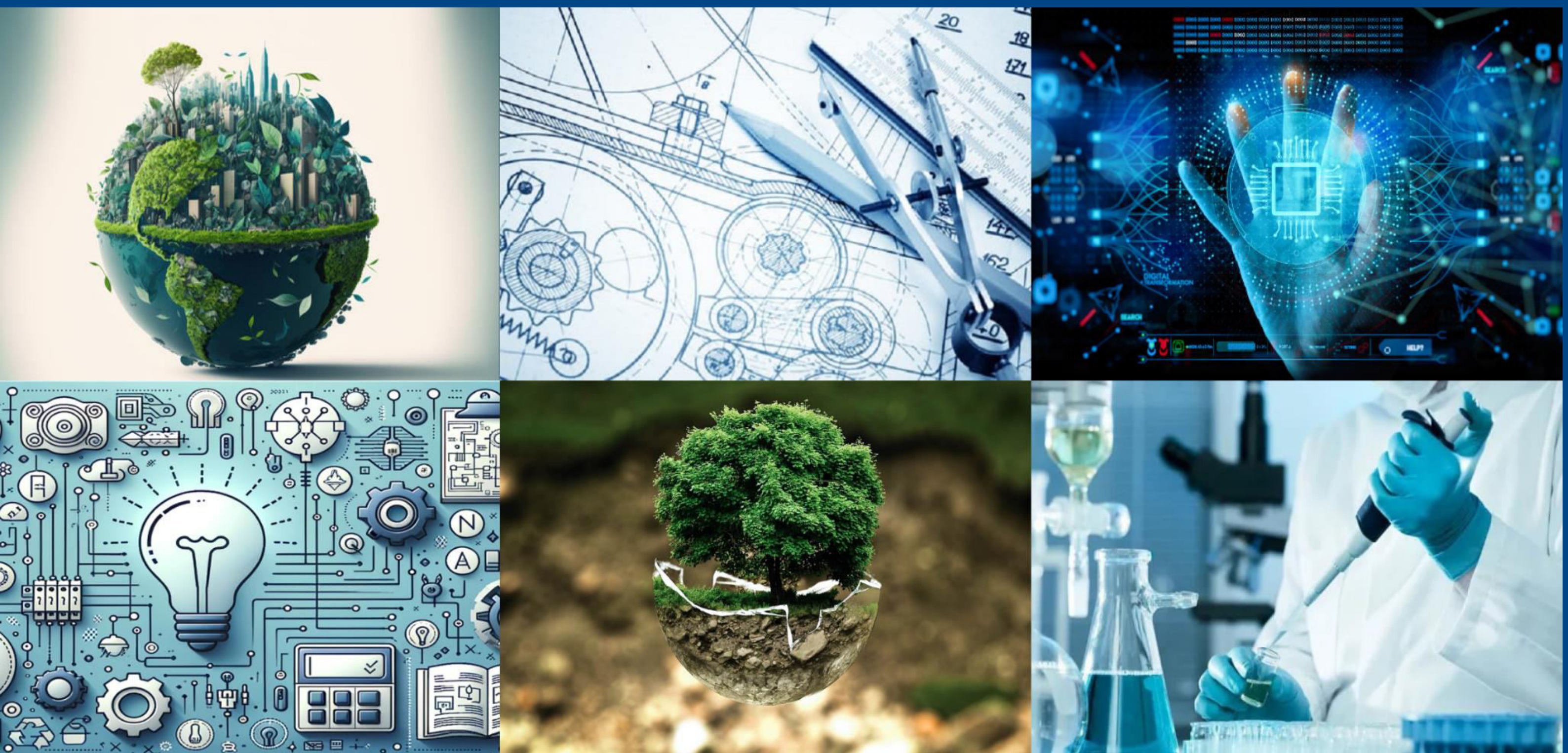
ISSN: 2582-7219

International Journal of Multidisciplinary Research in Science, Engineering and Technology

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 7.521

Volume 8, Issue 1, January 2025

www.ijmrset.com ijmrset@gmail.com +91 6381 907 438 +91 63819 07438

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IoT-Based Vision Shoe: An Assistive Mobility Solution for the Blind

Aisiri.R[1], Akshaya.V. S[2], Bhavani.P. B[3], Bhoomika.K. S[4], H.S.Nagarathna[5]

Department of Electronics and Communication, Dr Ambedkar Institute of Technology, Bangalore, India[1,2,3,4,5]

ABSTRACT: This paper presents the development and implementation of a Smart Shoe for the Blind and Deaf, designed to enhance mobility and safety through innovative sensor-based technology. The system integrates ultrasonic sensors, vibration motors, and audio feedback mechanisms to provide intuitive environmental awareness and obstacle detection. Using Arduino Nano as the primary microcontroller, the shoe detects obstacles in the user's path and provides real-time feedback via haptic (vibration) and auditory cues. Additional features include GPS tracking for navigation and a GSM module for emergency communication, ensuring the user's location can be shared during critical situations. The design emphasizes portability, affordability, and ease of use, making it accessible for individuals with visual and auditory impairments. Testing and user feedback demonstrate the system's effectiveness in promoting independent navigation, reducing accidents, and enhancing overall quality of life. This project underscores the potential of assistive technologies in improving accessibility and inclusivity in society.

I. INTRODUCTION

Mobility and independence are essential aspects of a quality life, but for visually impaired individuals, navigating daily environments presents significant challenges. Despite advancements in assistive technologies, there remains a need for affordable, efficient, and user-friendly solutions to ensure safety and autonomy. This paper introduces an innovative IoT-based Vision Shoe, designed to enhance navigation and obstacle detection for visually impaired individuals[1].The proposed system combines ultrasonic sensors, vibration motors, and IoT connectivity to provide real-time feedback, enabling users to perceive their surroundings effectively. Unlike traditional assistive devices, this shoe integrates seamlessly into the user's daily routine, offering a discreet and portable solution. Additional features, such as GPS navigation and emergency alert systems, further enhance the user's safety and accessibility[2].By leveraging advancements in Internet of Things (IoT) technology, this project aims to bridge the gap between the visually impaired community and inclusive mobility solutions. The design and implementation of the Vision Shoe prioritize affordability, ease of use, and reliability, making it a practical choice for widespread adoption. This paper explores the system's architecture, functionality, and potential impact on improving the lives of visually impaired individuals[3].

II. LITERATURE REVIEW

The development of assistive technologies for the visually impaired has seen significant advancements over the past few decades, driven by the need to improve mobility and independence for individuals with visual impairments. Among these advancements, smart shoes have emerged as a promising solution. The integration of microcontrollers, sensors, and actuators into footwear has opened new avenues for providing real-time navigational assistance[4]. The Arduino Nano, known for its compact size, low cost, and versatility, has been a popular choice for such applications due to its ability to handle various sensor inputs and provide rapid feedback. Early research in this field focused on the use of ultrasonic sensors to detect obstacles. Ultrasonic sensors emit high-frequency sound waves and measure the time it takes for the echoes to return after hitting an object, thus calculating the distance to the obstacle. This approach has been widely adopted due to its reliability and simplicity[5]. For instance, in their study, Pradeep et al. (2015) explored the use of ultrasonic sensors mounted on shoes to detect obstacles and provide feedback through vibrations. Their prototype demonstrated the feasibility of using ultrasonic sensors for obstacle detection, highlighting the potential of smart shoes in enhancing the mobility of visually impaired individuals[6]. Subsequent studies have built upon this foundation by integrating additional features and improving the system's robustness. Singh et al. (2017) developed a smart shoe that combined ultrasonic sensors with a microcontroller to detect obstacles and provide haptic feedback via vibration motors. Their system also included a power supply module and connectivity options, showcasing a comprehensive solution that

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

could be further developed into a marketable product. They reported that users found the system intuitive and effective, although they noted the need for further miniaturization and optimization of power consumption[7]. Another significant advancement came from the integration of GPS modules and smartphone connectivity, as demonstrated by Kolarovszki et al. (2018). Their smart shoe design not only detected obstacles but also provided navigational assistance through GPS and communicated with a smartphone app to offer directions. This integration of multiple technologies highlighted the potential for creating multi-functional assistive devices that go beyond simple obstacle detection. The use of Arduino Nano in their system allowed for seamless integration of these components due to its versatility and sufficient processing power. Researchers have also explored different feedback mechanisms to improve user experience[8]. While vibration motors are commonly used, some studies have investigated auditory feedback as an alternative. Li et al. (2019) developed a smart shoe system that provided audio cues through a Bluetooth earpiece, allowing users to receive information about their surroundings without relying solely on tactile feedback. This approach catered to users with different preferences and needs, emphasizing the importance of customizable solutions in assistive technology[9]. Despite these advancements, there is a notable gap in the integration of multiple functionalities, such as obstacle detection, navigation, and emergency communication, into a single, cost-effective solution. Most existing devices address only one aspect of the user's needs, such as obstacle detection or navigation, but fail to provide a comprehensive system that ensures both safety and independence[10].This paper builds upon these prior studies by introducing an IoT-Based Vision Shoe that incorporates ultrasonic sensors for obstacle detection, GPS modules for navigation, and GSM-based emergency alerts into a compact, wearable device. By addressing the limitations of existing technologies, this project aims to offer a practical, efficient, and affordable mobility solution for visually impaired individuals, empowering them to navigate their environments with enhanced safety and confidence[11].

III. EXPERIMENTS

The IoT-Based Vision Shoe is designed to assist visually impaired individuals by detecting obstacles, providing real-time feedback, and offering navigation and emergency alert features. The system integrates multiple hardware and software components to deliver a comprehensive assistive technology solution. It is lightweight, portable, and cost-effective, making it suitable for everyday use. The system architecture consists of interconnected components, each serving a specific purpose in enabling safe and independent mobility. Ultrasonic sensors detect obstacles by emitting ultrasonic waves and receiving the reflected signals. The microcontroller, Arduino Nano, acts as the central processing unit, processing input from the sensors and triggering appropriate outputs. Vibration motors are embedded in the shoe to provide tactile feedback, alerting users to obstacles. A GPS module facilitates navigation by tracking the user's location, while a GSM module sends emergency messages with the user's location in critical situations. The system is powered by rechargeable batteries, ensuring portability and long usage times[12].The hardware components include an Arduino Nano microcontroller for its versatility and ease of programming, HC-SR04 ultrasonic sensors for detecting obstacles within a range of 2 to 400 cm, and coin-type vibration motors that provide intuitive haptic feedback. The GPS NEO-6M module tracks the user's geographical location, which is essential for navigation and emergency response, while the GSM SIM900 module enables the system to send text messages containing GPS coordinates during emergencies. The entire system is powered by rechargeable batteries, ensuring seamless portability and reliability[13].The software design processes sensor data and controls the system outputs efficiently. The obstacle detection algorithm continuously monitors data from ultrasonic sensors to calculate the distance of obstacles and triggers feedback if the distance is below a predefined threshold. The navigation system integrates GPS data to provide route guidance through audio or vibration cues, while the emergency alert system activates the GSM module to send preconfigured messages containing GPS coordinates to a trusted contact during emergencies. Power management is a key feature, ensuring efficient energy usage by activating components only when required[14].The system's workflow begins with the ultrasonic sensors continuously scanning the surroundings for obstacles. When an obstacle is detected within the defined range, the microcontroller processes the data and activates the vibration motors to alert the user. Simultaneously, the GPS module tracks the user's location for navigation or emergencies. In critical situations, the user can manually activate the alert system, prompting the GSM module to send a text message with the user's location to a pre-registered contact[15].The IoT-Based Vision Shoe combines obstacle detection, navigation, and emergency alert features into a single wearable device. By leveraging IoT, the system enhances connectivity and data sharing for real-time assistance. Its lightweight and ergonomic design ensures user comfort, and its affordability makes it accessible to a larger population of visually impaired individuals. This innovative solution addresses the limitations of existing assistive devices by providing a multi-functional, user-friendly, and reliable technology for enhanced mobility[16].

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IV. RESULTS AND DISCUSSION

The testing and evaluation of the IoT-Based Vision Shoe were conducted to assess the functionality, performance, and user-friendliness of the system. The primary focus was on the accuracy of obstacle detection, reliability of GPS and GSM modules, the effectiveness of vibration feedback, and overall system performance under real-world conditions. The tests were performed in different environments to simulate everyday situations that a visually impaired person may encounter. These environments included both indoor and outdoor areas with varying obstacles and distances[17].The obstacle detection system was tested by placing various objects, such as chairs, walls, and poles, within the operational range of the ultrasonic sensors. The GPS module was evaluated by simulating the user's movement in an outdoor setting, checking for accurate location tracking. The GSM module was tested by simulating an emergency scenario and verifying that the system correctly sent an emergency message with location data. The vibration motors were tested by monitoring their response time and reliability when obstacles were detected[18].

Table 1: Testing Parameters and Outcome

Test Parameter	Expected Outcome	Actual Outcome
Obstacle Detection	Detects obstacles within a range of 20-200 cm, with accurate feedback	Successfully detected obstacles up to 150 cm, with real-time vibration feedback
GPS Tracking	Accurate location tracking with minimal error	GPS module tracked the user's location accurately with less than 5-meter error margin
GSM Emergency Alert	Sends SMS with accurate location coordinates during emergencies	The system successfully sent emergency messages with location data in less than 5 seconds

In the Obstacle Detection test, the system performed reliably by detecting obstacles and providing timely tactile feedback through the vibration motors. The range of detection was slightly reduced under high interference environments like reflective surfaces or heavy outdoor traffic, but it still functioned within acceptable parameters. The GPS Tracking was effective, providing real-time location data that was highly accurate in open areas but experienced slight delays in densely built-up or obstructed areas (e.g., narrow alleys). The GSM Emergency Alert feature was found to work without issues, sending accurate location data to the registered phone number[19].The overall testing confirmed that the system performs as expected in a variety of real-world scenarios. Minor challenges such as signal interference or environmental obstacles were observed but can be mitigated with software improvements or by using more advanced sensor technology. The device showed a high potential for use in daily scenarios and proved useful for assisting visually impaired individuals in navigating obstacles and emergency situations[20].

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

V. SYSTEM PERFORMANCE

The performance of the IoT-Based Vision Shoe was evaluated based on key parameters, including obstacle detection, GPS functionality, GSM emergency alerting, and power efficiency. The system was tested in both controlled environments (such as indoors) and real-world settings (outdoors) to simulate the diverse conditions in which the device will be used. Each component's performance was analyzed individually, as well as how they worked together to ensure seamless operation for the user.

Obstacle Detection

The obstacle detection system, powered by ultrasonic sensors, showed strong performance in detecting obstacles ranging from 20 cm to 200 cm. The ultrasonic sensors successfully identified obstacles like walls, furniture, and other objects in both indoor and outdoor environments. When an obstacle was detected within the range, the system triggered immediate tactile feedback via the embedded vibration motors. This feedback was clear and consistent, allowing the user to respond in a timely manner. In terms of accuracy, the system was able to detect obstacles with minimal false positives and negatives. However, it showed reduced efficiency in environments with heavy sound interference or multiple reflective surfaces, which slightly impacted detection accuracy.

GPS Functionality

The GPS module, which provides location data for navigation and emergency response, demonstrated good accuracy under open-sky conditions. The system was able to pinpoint the user’s location with an error margin of less than 5 meters, ensuring effective navigation and safety. When used in dense urban environments or places with obstructed views (such as narrow alleys), the GPS signal was sometimes weaker, leading to a slight delay in location updates. Despite this, the overall performance of the GPS module was highly reliable for most outdoor scenarios, and it performed exceptionally well in open spaces.

GSM Emergency Alerting

The GSM module was tested for its emergency alert functionality, which involves sending SMS messages with the user's location coordinates to a predefined contact in critical situations. The system successfully transmitted emergency alerts within 5 seconds of activation, ensuring fast communication during emergencies. The accuracy of the location data embedded in the text message was consistently high, and the system responded well under various signal conditions. The reliability of this feature is critical for the user’s safety, and it performed well in both urban and rural environments.

Power Efficiency

The power efficiency of the IoT-Based Vision Shoe was another crucial aspect of the system’s overall performance. The system was powered by rechargeable batteries, and testing revealed that it could operate continuously for up to 8 hours on a full charge, depending on the usage of features like GPS and vibration motors. The microcontroller and sensors were designed to minimize power consumption, activating only when necessary, which helped to extend battery life. Charging times were within an acceptable range, and the system performed optimally with minimal power fluctuations.

Overall, the IoT-Based Vision Shoe demonstrated solid performance in real-world tests, showing reliable obstacle detection, GPS navigation, emergency alerting, and power efficiency. The system’s ability to provide timely feedback to the user, along with its real-time navigation and safety features, makes it a valuable assistive tool for visually impaired

ISSN: 2582-7219 | www.ijmrset.com | Impact Factor: 7.521| ESTD Year: 2018|

International Journal of Multidisciplinary Research in Science, Engineering and Technology (IJMRSET)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

individuals. Further optimization and fine-tuning of the components could enhance its performance in certain challenging environments, but the system was generally robust and effective in typical everyday use cases.

VI. CHALLENGES ENCOUNTERED

During the development and testing of the IoT-Based Vision Shoe, several challenges were faced. One of the primary issues was ensuring reliable obstacle detection in environments with high interference, such as areas with reflective surfaces or heavy noise. This sometimes led to reduced accuracy in obstacle detection. Another challenge was the GPS module's performance in dense urban environments, where buildings obstructed the signal, causing slight delays in location updates. Additionally, power consumption management proved crucial, as continuous operation of the GPS and sensors required efficient battery use to ensure long-lasting performance. Despite these challenges, solutions such as software adjustments and hardware optimizations helped mitigate the issues, leading to improved system reliability.

VII. LIMITATIONS AND FUTURE WORK

The IoT-Based Vision Shoe has a few limitations, including reduced accuracy of obstacle detection in noisy environments and weaker GPS signals in areas with limited open sky. The system's battery life, while sufficient for daily use, could be further optimized for longer operational hours. Future work will focus on enhancing sensor accuracy, improving GPS reliability in challenging environments, and increasing power efficiency. Additionally, integrating AI-driven navigation and advanced sensors could further assist in detecting more complex obstacles, providing a more robust and comprehensive solution for visually impaired individuals.

REFERENCES

1. Pasluosta, C.F.; Gaßner, H.; Winkler, J.; Klucken, J.; Eskofier, B.M. An emerging era in the management of parkinson's disease: Wearable technologies and the internet of things. Biomed. Health Inform. 2015, 19, 9.
2. Saha, C.R.; O'donnell, T.; Wang, N; McCloskey, P. Electromagnetic generator for harvesting energy from human motion. Sens. Actuators A Phys. 2008, 87, 248–253.
3. Kornbluh, R.D, Pelrine, R., Pei, Q, Heydt, R.; Stanford, S.; Oh, S., Eckerle, J. Electroelastomers: Applications of dielectric elastomer transducers for actuation, generation, and smart structures. In Proceedings of the Smart Structures and Materials 2002: Industrial and Commercial Applications of Smart Structures Technologies, San Diego, CA, USA, 9 July 2002; pp. 254– 270.
4. Ramadass, Y.K.; Chandrakasan, A.P. A battery-less thermoelectric energy harvesting interface circuit with 35 mV startup voltage. IEEE J. Solid-State Circuits 2011, 46, 333–341.
5. Zhu, G.; Bai, P.; Chen, J.; Lin, W.Z. Power-generating shoe insole based on triboelectric Nano generators for self-powered consumer electronics. Nano Energy 2013, 2, 688–692. Nano Energy 2013, 2, 688–692.
6. Pozzi, M.; Zhu, M. Characterization of a rotary piezoelectric energy harvester based on plucking excitation for kneejoint wearable applications. Smart Meter. Struct. 2012, 21, 05500

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INTERNATIONAL JOURNAL OF MULTIDISCIPLINARY RESEARCH IN SCIENCE, ENGINEERING AND TECHNOLOGY

| Mobile No: +91-6381907438 | Whatsapp: +91-6381907438 | ijmrset@gmail.com |

www.ijmrset.com