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# Sole-Sense: An Intelligent Footwear System for Perceptive Navigation Assistance

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***Abstract:*** ***Recent developments in IoT have equipped wearable intelligent devices to assist visually impaired individuals in daily navigation. Smart walking shoes have recently emerged as a promising device due to their uninterrupted, hands-free functionality. This literature review raises awareness about the available IoT-enabled smart shoes developed in the period spanning 2023-2025. The existing literature showed that most of the developed systems mainly included ultrasonic sensors, cameras, and GPS, along with an onboard processor for obstacle detection and environmental awareness as well as live notifications via Vibration and Voice outputs. There were also many studies incorporating AI with smartphone interaction assistance for enhanced perception and interaction capabilities. Approaches surveyed in this paper are categorized based on sensing techniques and system intelligence and compared based on their functionality, cost, and usability. Some major challenges associated with the accuracy of the sensors, energy efficiency, comfort, and real-world performance are discussed. Finally, this survey identifies research lacuna and outlines the future directions for developing smart footwear.***

**Keywords: IoT, Smart Walking Shoes, Assistive Technology, Visually Impaired Navigation, Sensors**

## I. INTRODUCTION

Independent mobility is one of the toughest situations faced by visually impaired people, as this aspect is directly related to their life. In order to help a visually impaired person, various tools such as white canes and guide dogs are often utilized; however, they do come with some drawbacks. White canes can help identify obstacles only at ground level up to a short distance, whereas guide dogs are very costly to train. The key disadvantage with the utilization of white canes and guide dogs is their inability to identify dynamic obstacles. Nevertheless, due to recent improvements in the technology of embedded systems, sensors, and Internet of Things technology, the development of smart assistive devices has become easier. Wearable technology stands to benefit the most, as these devices are portable, discreet, and provide continuous and real-time monitoring. Among various options for wearables, smart walking shoes are becoming popular, as they seamlessly merge the detection and feedback system with shoes, hence not requiring any sort of handheld tool or any assistive tool.

Internet of Things-enabled intelligent walking footwear has been designed with the ability to detect obstacles, irregularities on the path, and risks from the environment at a real-time level with the use of sensors and microcontrollers. This has been made possible in order to provide the user with immediate feedback on their navigation with the use of vibrations and/or sound signals. The use of an IoT element makes it possible for interaction with either a smartphone or the cloud for data analysis. Over the past few years, research has been dominated by improving the accuracy, intelligence, and usability of intelligent walking shoes by employing sophisticated sensing methods and artificial intelligence as well as location-aware services. This survey paper thoroughly reviews recent research work done in the area of using IoT for intelligent walking shoes to improve the mobility of visually impaired people by overcoming the challenges faced by existing research.

## II. LITERATURE SURVEY

Smart Shoe for Visually Impaired: This project proposes a smart shoe system that contains ultrasonic sensors, vibration modules, and Bluetooth technology. The proposed system [1] aims to help the visually impaired navigate towards their destination and provide them with warnings about approaching obstacles using a vibration feedback system. The proposed system increases individual navigation capabilities but does not provide a water-detecting system. As a drawback of not incorporating a water-detecting system, the system's electronic devices could be damaged if used in a wet environment. Moreover, the system [2] doesn't contain a step-detecting system, and therefore, it is not capable of determining the number of steps left to reach an obstacle or calculating the approximate distance to the obstacle.

Smart Navigational Shoes for the Blind - Obstacle Detection. This paper suggests the conceptual design of the smart shoe for the blind, which uses sensors for the detection of obstacles and vibrators as direction indicators. An IR sensor is used for the identification of the obstacle in the path of the user. On detecting the obstacle, a buzzer is triggered to inform the user. There is also the use of a water sensor for the identification of the presence of water in the road, [3] and the data is shown on the LCD screen. Though the design allows for the identification of the obstacle and the presence of water, it doesn't offer the functionality of the step count to the obstacle, which lowers the position accuracy.

Improved Shoes for Blind Individuals. This research offers a sophisticated shoe design with the capability to detect an obstacle within a defined range by utilizing ultrasonic sensors. Vibration motors are employed to indicate the obstacle's direction to the user. [4] Though this design helps in obstacle

detection, it lacks a water sensor. This makes the shoe system susceptible to damage in a water environment. In addition to this limitation, it neither has GPS functionality to assist in routing nor a step counter to correctly locate the obstacle's position with regard to the user.

Wearable Obstacle Detection System for Visually Impaired Individuals. This paper presents a wearable system for obstacle detection and is designed to assist visually impaired persons during their locomotion activities. [5] The proposed system uses ultrasonic sensors and is responsible for determining the closest obstacle and sending vibro- tactile warnings regarding its existence and position. The major function of this system is to assist in improving user mobility by expanding their senses. However, this system does not have a water detection function and could result in damage during wet weather situations. The system also lacks an obstacle detection function based on step counts for accurate obstacle positioning.

Wearable Navigation Assistance - A Tool for the Blind. This paper describes an electronic support tool for navigation designed for visually impaired persons. [6] The proposed system uses a multi-sensor technology scheme consisting of stereo vision, audio distance measurement, motion sensors, and a map processing module, warning system, and touch- based human- machine interface. [7] The purpose of this invention is to assist visually impaired persons to safely navigate their surroundings, and it aims to avoid any collisions. The system has limitations when it comes to water detection, which can affect its hardware safety. In addition, it lacks a step counter to precisely calculate the distance of any obstacle.

## III. OBJECTIVE

Blind and visually impaired individuals encounter various problems during independent mobility in outdoor as well as indoor settings. The major aim of this project is to create an Internet of Things-based smart walking shoe for aiding the visually impaired to navigate safely. The solution has been designed to identify any obstacle in front of the person and give them real-time feedback in terms of vibration signals. Based on ultrasonic sensing technology, the proposal helps to overcome the hazard of collisions and, therefore, accidents for visually impaired individuals.

## IV. EXISTING SYSTEM

One commonly used assistive mobility device among the visually impaired community is the white stick or cane, which assists in the detection of obstacles immediately in front of the user. Despite the system's simplicity and low cost, it has some disadvantages.

This system cannot detect obstacles that are a distance away, above ground level, or those that could potentially harm the user as a result of pits, stairs, or other uneven surfaces. Based on the system's disadvantages, it is a challenge for a blind person to safely move without assistance. The reach of the white cane is limited, and the cane is unable to detect obstacles at a distance or elevated from the ground. The information obtained is not about moving obstacles such as cars or people.

The user experiences a high degree of reliance on experience and concentration. This is mentally straining when overexerted for a ong time. The information obtained by the cane is not about environmental hazards such as uneven terrain or holes.

Figure 1 : Smart stick

## V. PROPOSED SYSTEM

One such system that can be proposed involves an intelligent walking shoe that facilitates the integration of ultrasonic sensors, along with IoT devices, such that the shoe can sense its surroundings and inform the user regarding the presence of obstacles within a specific range. For this purpose, the ultrasonic sensors would be interfaced with the microcontroller, which would process the received information, and the user would be provided with feedback, such as vibration and audio feedback. The major aim associated with this system would be related to providing support to the visually impaired such that the person can move freely and safely without being exposed to accidents. For this purpose, the smart shoe that is developed can be considered an assistive tool that would provide support to the visually impaired. The various hardware components used in the intelligent walking shoe system and their respective functions are explained in the following section


Figure 2 : Smart shoe

### *5.1 Arduino Uno*

Arduino Uno is a small, affordable, and easy-to-use open-source microcontroller system board with huge potential in embedded system and IoT-based projects alike owing to its ease of use and affordability. The main controller or the main controlling unit of the intelligent walking shoe system based on the Arduino Uno is the Arduino Uno board itself, as here it is responsible for collecting the information from different sensors, processing it, and finally managing the output device. The Arduino Uno board works quite efficiently in terms of handling the ultrasonic sensors along with feedback devices in order to generate an alert or notify the user about the presence of any obstacle. The Arduino Uno is quite suitable in terms of ease of use owing to its simplicity and reliability.

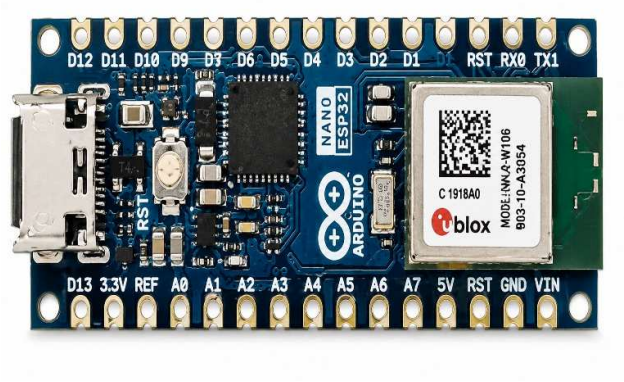


Figure 3 : Arduino UNO

### 5.2 *Node MCU*

The NodeMCU, on the other hand, is used as a development board in the development of IoT projects, specifically in the development of IoT projects due to its open-source characteristics and is commonly employed in prototyping. It primarily makes use of the ESP8266 SoC, which essentially provides access to the internet in the most affordable manner. When it comes to the development of the intelligent walking shoe system, the NodeMCU can be employed to enable communication, replacing the idea of IoT by transmitting the sensor signals to other devices or applications.

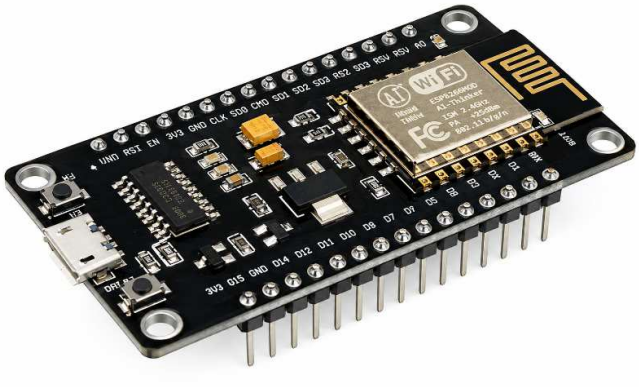

Figure 4 : NodeMCU

### 5.3 *Ultrasonic Sensor (HC-SR04)*

The ultrasonic sensor operates based on the working principle of sound wave reflection, similar to the SONAR technique, to measure the distance of nearby objects. It transmits ultrasonic pulses and calculates the time taken for the echo to return after hitting an obstacle. In the intelligent walking shoe system, this sensor is used to detect obstacles present in the user's path and provide distance information to the controller. This enables timely alerts and helps visually impaired users avoid collisions.


Figure 5 : Ultrasonic Sensor (HC-SR04)

### 5.4 *IR Sensor*

The infrared sensor is also used to detect slopes, steps, and changes in level on the walking surface. An infrared sensor operates by transmitting infrared rays and detecting their reflections on nearby surfaces. The device operates in a similar manner to object sensing. In the intelligent walking shoe system, the IR sensor is used to detect uneven walking surfaces and downward paths.

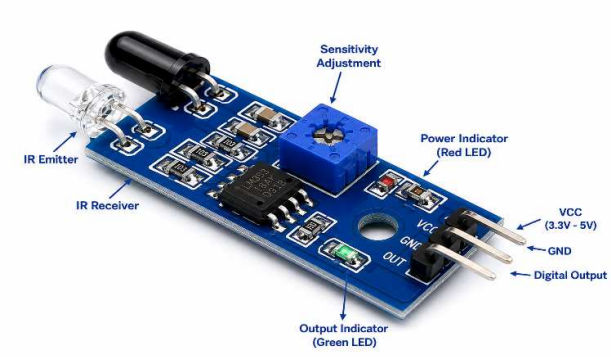


Figure 6 : IR sensor

## VI. RESULT AND ANALYSIS

The designed intelligent walking shoe with IoT technology was able to detect obstacles and ground hazards in real time, providing instant vibration feedback to the user. The GPS module was able to monitor the user's location outdoors and

send the information to the user via IoT communication. The system was able to improve navigation safety and facilitate independence in mobility for the visually impaired.

## VII. CONCLUSION

The designed intelligent walking shoe for IoT provides helpful assistance to visually impaired people for navigating their environment in a safe and confident manner. By using multiple sensors, the system is capable of detecting obstacles, terrain, and dangerous spots, and then providing the user with vibration feedback. The inclusion of GPS position tracking with IoT connectivity provides a further safety feature for the visually impaired user. The system is found to be a very practical, economical, and effective assistance tool that can improve the mobility of visually impaired people.

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