Sensor-Integrated Smart Footwear System

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***Abstract*—People's lives have become easier and simpler as technology has proliferated. The biggest problem for blind people is figuring out how to get where they want to go. People with good eyesight need to help these people. Smart footwear is a technique that helps blind people find their way when they walk. So, a special footwear has been made to help blind people walk safely without worrying about running into other people or solid objects. The system integrates dual ultrasonic sensors to detect obstacles in front and at ground level, with an Arduino Nano serving as the control unit. Real-time buzzer and vibration alerts warn the user of nearby obstacles, while an SOS feature with GPS and GSM enables location sharing during emergencies.**

***Index Terms*—Blind People, Smart Footwear, Vibration Alert, SOS Feature, Emergencies.**

I. INTRODUCTION

People who are visually impaired or blind have limited eyesight and are unable to see fine details. The World Health Organization (WHO) reports that approximately 70 million people globally, or 1% of the population, have visual impairments. Of these, 7 million are considered blind, and 63 million have poor vision. Magnitude, temporal trends, and safety system of the global prevalence of blindness. The main problem with blind people is how to go anywhere they want. These people frequently need help from others with good eyesight. As described by WHO, 10 percent of the visually impaired have no functional eyesight at all to help them move around without assistance and safely. Blind individuals face significant challenges in navigating and moving safely through their environment. To address this problem, we developed an intelligent footwear safety system to improve the safety and independence of blind individuals by providing real-time guidance and assistance in navigating their environment. The system uses front and bottom ultrasonic sensors to detect obstacles and surface variations in real time. An Arduino Nano controls the system and triggers buzzer and vibration alerts to warn the user. An SOS feature with GPS and GSM enables emergency location sharing, improving safety and independent mobility.

II.LITERATURE REVIEW

1] Tejal Chandekar et al., in this paper they have surveyed the existing solutions meant for autonomous mobility for the visually impaired people as well as proposed a novel design, Smart Shoes with embedded sensors to guide a visually impaired person while navigating and to alert him or her of the obstacles that lay ahead in his path. The design is aimed to develop an easy-to-use Android application to cater to the special needs, used to guide the person coextending the features of the Smart Shoes.

2] Ammar Almomani et al., in this research, they are making a new safety system and a smart shoe for blind people. The system is based on Internet of Things (IoT) technology and uses three ultrasonic sensors to allow users to hear and react to barriers. It has ultrasonic sensors and a microprocessor that can tell how far away something is and if there are any obstacles. Water and flame sensors were used, and a sound was used to let the person know if an obstacle was near him. The sensors use Global Positioning System (GPS) technology to detect motion from almost every side to keep an eye on the means to ensure they are safe. To test their proposal, they gave a questionnaire to 100 people. The questionnaire has eleven questions, and 99.1% of the people who filled it out said that the product meets their needs.

3] Om Bagul et al., this paper presents a novel design and development of smart shoes integrated with Arduino Nano, GSM, and GPS technologies. The system aims to provide real-time tracking, safety features, and emergency alerts for individuals, particularly women and children. The smart shoes utilize Arduino Nano to process data from GPS and GSM modules, enabling location tracking and communication with authorities and family members. The system features a panic button, voice assistant, and accelerometer-based unusual activity detection. The shoes are designed to be compact, wearable, and user-friendly. The proposed system has the potential to enhance safety, reduce response time in emergencies, and provide peace of mind for individuals and their loved ones.

4] Pradeepa R et al., this paper introduces a thought regarding managing the issues looked by blind people through smart shoes. Due to the blind people face many challenges especially when moving in public places. 285 million people are estimated to be visually impaired worldwide out of which 39 million people are blind and 246 have low vision. Smart shoes will help a blind person to move on independently with the help of ultrasonic sensors to detect obstacles. In this paper presents various smart shoes for blind technology using Internet of Things.

5] Malarvizhi Ram et al., Trips and slips are significant causal perturbations leading to falls on stairs, especially in older people. The risk of a trip caused by a toe or heel catch on the step edge increases when clearance is small and variable between steps. The risk of a slip increases if the proportion of the foot area in contact with the step is reduced and variable between steps. To assess fall risk, these measurements are typically taken in a gait lab using motion-capture optoelectronic systems. The aim of this paper was to develop a novel smart shoe equipped with sensors to measure foot placement and foot clearance on stairs in real homes. To validate the smart shoe as a tool for estimating stair fall risk, twenty-five older adults' sensor-based measurements were compared against foot placement and clearance measurements taken in an experimental staircase in the lab using correlations and Bland–Altman agreement techniques. The results showed that there was a good agreement and a strong positive linear correlation for foot placement ($r = 0.878$, $p < 0.000$) and foot clearance ($r = 0.967$, $p <0.000$) between sensor and motion analysis, offering promise for advancing the current prototype into a measurement tool for fall risk in real-life staircases.

6] Priti Rane et al., this paper aims at developing a Smart Shoe. The principal intention of this paper is to establish a smart shoe setup which will function as a health tracker. This paper aims towards fitness as it helps in counting the footsteps taken by a human and in turn calculates the calories burnt. The shoe itself generates the energy which is required to drive this system. This energy can even be used to charge a mobile phone.

7] Rishitha Veeramalla et al., this paper illuminates all the problems, issues faced by human behaviours. The purpose of this proposed system is to come up with a device that acts as an aid to the visually impaired, mentally unstable, people who lost their vision due to age or kids. The main features of the smart shoes are obstacle detection, range detection and alerting the user. There is scope for improvement in this paper. Some more features can be added, and this system can be developed more consistently.

8] Dr. Kamalraj R., et al., this paper aims to find out how human-centered design principles and machine learning algorithms can work together to create smart footwear for visually impaired people. The examination plans to connect feel, usefulness, and knowledge to work on clients' general portability, solace, and security. In order to make sure that the brilliant shoes meet the unique needs of people who have visual impairments, human-driven plan approaches are investigated to address the nuances of comfort, ease of use, and customer satisfaction. AI calculations are utilized at the same time to fit the footwear's usefulness to individual inclinations, including pace, strolling styles, and different natural circumstances. This examination means to foster a complete and easy to use arrangement that meets the particular necessities of clients as well as sticks to moral contemplations in assistive innovations through a multidisciplinary approach that includes joint effort between specialists in plan, designers, and AI. The review depends vigorously on ease-of-use testing and client input to acquire knowledge into the savvy footwear's functional viability. Moreover, the review inspects inclusivity, considering an extensive variety of client necessities as well as potential challenges connected to different social and ecological settings. In conclusion, this paper imagines a future in which visually impaired individuals will have access to individualized and inclusive mobility solutions made possible by intelligent footwear that seamlessly combines aesthetics and intelligence.

9] Dr. A. Kingsly Jabakumar et al., Power of sight is considered as the most important of all senses. Blind people are often dependent on others for their daily tour. Over time several advancements in technology have helped in increasing entertainment and comfort for the blind. “Smart shoes" can assist the blind in their daily routine and can act as a comfortable and safe companion on their journey. Common assistance provided earlier for the blind include walking sticks or guide dogs. It includes ultrasonic sensors with a step counter that can alert the person of the impending obstacles. The technology results can improve their ways of growth and can drive them to lead their independent lives. Medical assistance can be provided depending on the pattern of the walk. The electronic hardware will be fixed in shoes for users. Users will wear the shoe and travel anywhere, and attached sensors will sense obstacles near to the shoe’s alerts with the help of visually impaired people. India contributes about 21% of the blind people over total population.

10] C. K. Lakde et al., Navigation assistance for visually impaired (NAVI) refers to systems that are able to assist or guide people with vision loss, ranging from partially sighted to totally blind, by means of sound commands. Many researchers are working to assist visually impaired people in different ways like voice-based assistance, ultrasonic based assistance, camera-based assistance and in some advance way researchers are trying to give transplantation of real eyes with robotic eyes which can be capable enough to plot the real image over patient retina using some biomedical technologies. In other ways creating a fusion of sensing technology and voice-based guidance systems some of the products were developed which could give better results than individual technology. There are some limitations in systems like obstacle detection which could not see the object but detection of the object and camera-based system can't work properly in different light levels so the proposed system is a fusion of color sensing sensor and the obstacle sensor along with the voice-based assistance system. The main idea of the proposed system is to make a person aware of the path he is walking and also the obstacle in the path.

III. METHODOLOGY

The proposed sensor-integrated smart footwear system is designed to support safe and independent mobility for visually impaired individuals through real-time environmental awareness and emergency assistance. The system embeds two ultrasonic sensors, positioned at the front and bottom of the footwear, to continuously monitor obstacles and surface variations during walking. An Arduino Nano microcontroller serves as the core processing unit, analysing sensor inputs and coordinating system responses. When an obstacle or uneven surface is detected within a predefined range, the system generates immediate feedback through a combination of auditory alerts using a buzzer and tactile alerts using a vibration motor. Additionally, an SOS mechanism is incorporated, allowing the user to transmit their real-time geographic location via integrated GPS and GSM modules to predefined emergency contacts. This compact, low-power, and wearable solution enhances user safety while minimizing dependence on external assistance.

❖ Block Diagram

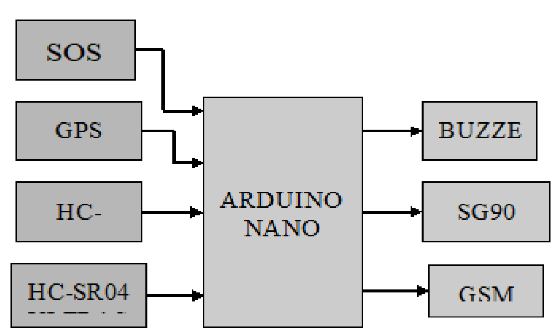

Fig. 1 Shows the Block Diagram of the Proposed System

Description

In the given Block diagram, we have used the Arduino Nano as a microcontroller. In input devices, we have used two HC-SR04 Ultrasonic Sensors, GPS Module & SOS Button connected to the microcontroller. In the output devices, we have used a Buzzer, GSM Module and an SG90 Servo Motor connected to the microcontroller.

❖ Flow Chart

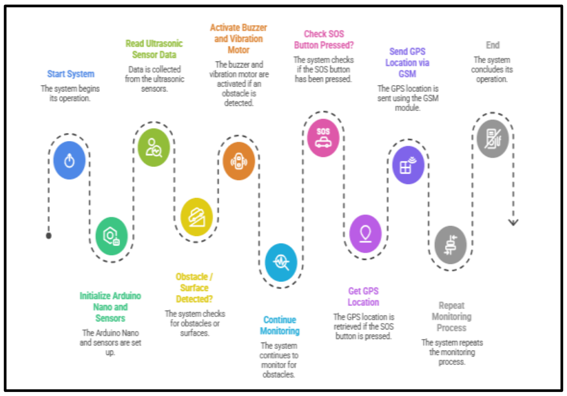

Fig. 2 Shows the Flowchart of the Proposed System

Working

The Sensor-Integrated Smart Footwear System is designed to assist visually impaired individuals by detecting obstacles and providing timely alerts while walking. The system uses two ultrasonic sensors placed on the footwear. The front ultrasonic sensor continuously checks for obstacles in the walking path, while the bottom sensor monitors the ground to detect sudden changes in surface level. Both sensors measure the distance to nearby objects and send this information to the Arduino Nano microcontroller, which acts as the main control unit of the system.

When the front ultrasonic sensor detects an obstacle within a specific range, the Arduino Nano immediately activates a buzzer and a vibration motor to alert the user. These audio and vibration signals help the user become aware of the obstacle and take necessary action to avoid it. In case of an emergency, the user can press the SOS button integrated into the system. Once pressed, the Arduino collects the current location through the GPS module and sends this information via the GSM module. This feature ensures that the user can quickly share their location and receive assistance when needed.

IV. SYSTEM REQUIREMENT

Hardware Requirement

1] Arduino UNO
2] Ultrasonic Sensor (HC-SR04) * 2
3] GPS Module (NEO-6M)
4] GSM Module (SIM800L)
5] SG90 Servo Motor
6] SOS Button
7] 5V Buzzer

Software Requirement

1] Arduino IDE
2] Proteus

V. EXPERIMENTAL SETUP & RESULT

Experimental Setup

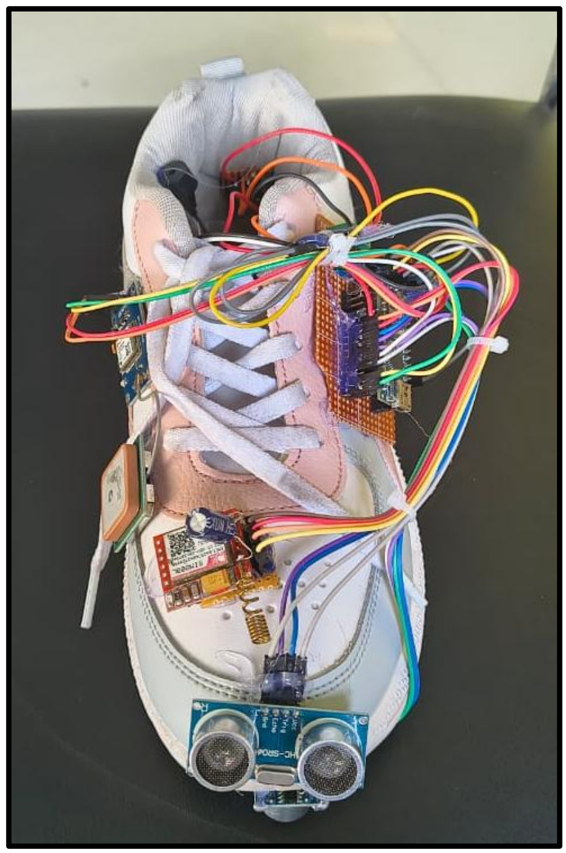

Fig. 3 Shows the Front View of the Experimental Setup

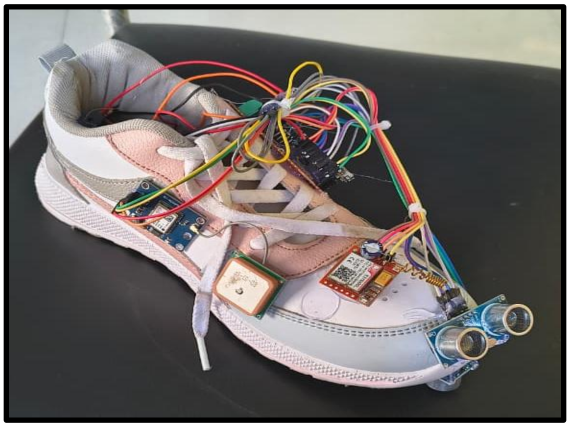

Fig. 4 Shows the Left Side of the Experimental Setup

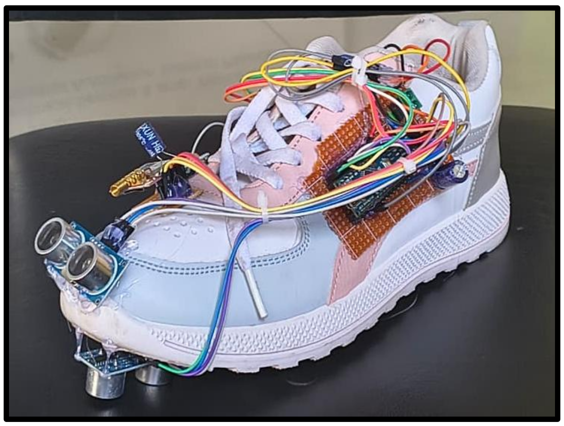

Fig. 5 Shows the Right Side of the Experimental Setup

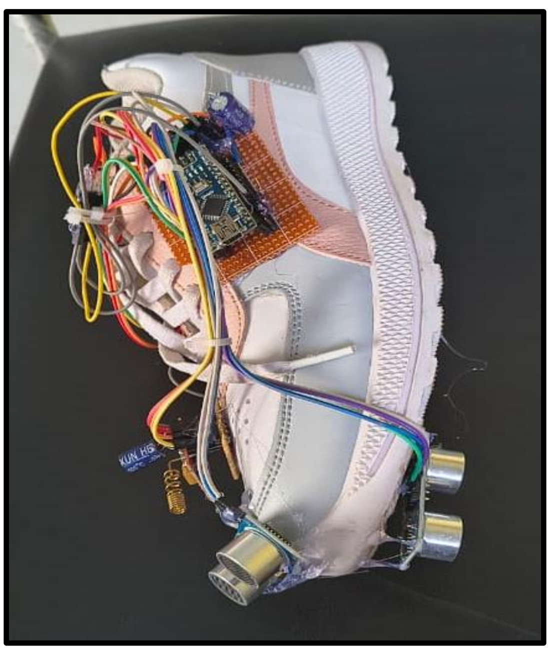

Fig. 6 Shows the Side View of the Experimental Setup

VI. RESULT

The developed sensor-integrated smart footwear system was tested to verify its ability to support safe movement for visually impaired users. During testing, the ultrasonic sensors effectively detected obstacles in front of the user as well as changes in the ground level. Whenever an obstacle was detected within the set distance, the system immediately produced alerts through the buzzer and vibration motor, helping the user become aware of potential hazards while walking. The response of the system was quick and consistent. Additionally, the SOS feature functioned properly by sending the user's current location through the GPS and GSM modules when the emergency button was pressed. Overall, the system demonstrated reliable performance and showed potential to improve safety and independence for visually impaired individuals.

VII. CONCLUSION

The sensor-integrated smart footwear system presents an effective wearable solution to enhance the safety and independence of visually impaired individuals. By combining ultrasonic-based obstacle detection with real-time audio and vibration alerts, the system supports safer navigation in both indoor and outdoor environments. The inclusion of an SOS feature with GPS and GSM further strengthens user security by enabling quick emergency communication. Overall, the proposed system demonstrates the potential of compact, sensor-driven assistive technology to improve mobility and quality of life for visually impaired users.

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