INTELLIGENT OBSTACLE DETECTION FOOTWEAR FORTHE VISUALLY IMPAIRED

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Abstract- While sight is a priceless gift that makes it easier for us to engage with the outside world on a daily basis, some people lack this ability and without it, it is difficult to navigate public areas. An Internet of Things-based Smart Shoe System is suggested as a wearable solution for the visually handicapped in order to address this. With the help of an ESP32 microcontroller and ultrasonic sensors, this system attempts to facilitate communication between actual items and people. With 1.6 million of those affected being children, there are over 40 million blind persons in India alone. This underscores the pressing need for solutions that enable independent movement. Especially when it comes to roadways, canes and other traditional aids are not always enough to identify every obstacle. By providing consumers with safety and autonomy during navigation, the Smart Shoe System presents a sustainable solution.

Keywords: Internet of things, Infrared, Light emitting diode, electronic travelling aid, eccentric rotating mass, integrated development environment, Global Positioning System, Alternative current, direct current.

I. INTRODUCTION

Our project centers on the fundamental idea of the Internet of Things, with a particular emphasis on enabling communication between tangible items by creating Smart Shoes designed for individuals with visual impairments. These shoes will include a variety of sensors and multifunctional features to help those with vision problems navigate to their destinations. Especially in difficult environments, traditional instruments like the long Hoover Cane frequently prove inadequate for efficient transportation. Intelligent footwear technology known as "Smart Shoes" uses smartphone software to do functions that are not possible with traditional shoes, like self-lacing features or vibrating notifications from Google Maps that provide navigation instructions. Those who are visually impaired can become more mobile and independent, depending less on others, by wearing these inventive shoes.Using sensors and vibrators, our system can sense and communicate information about the environment to the wearer, acting as a navigational and safety aid. With millions of people worldwide suffering from visual impairments and India making up around 21% of the world's blind population, the use of smart shoes presents a promising way to improve independent mobility for the blind. Smart shoes use ultrasonic sensors to detect obstacles and enable autonomous movement.

II. SMART SHOES FOR THE VISUALLY IMPAIRED

The smart shoe is a revolutionary tool for helping people with vision impairments independently traverse public settings. For people who are visually impaired, navigating obstacles like potholes, fire hydrants, and staircases can be very difficult. This novel footwear solution uses sensors to identify obstacles and provide users with vibratory, visual, and audio alerts. The smart shoe's integrated battery, ultrasonic sensors, processing unit, and wireless smartphone connectivity are all housed in a tough, weather-resistant casing that guarantees dependability and longevity in a variety of environmental circumstances.

III.OBSTACLE DETECTION

The smart shoes employ various methods to detect obstacles and issue warnings using predefined feedback options. Firstly, haptic or vibration feedback directly on the shoe alerts users to obstacles in their path. Secondly, acoustic feedback can be received via a Bluetooth-connected smartphone or bone-conduction headphones. Additionally, visual feedback is provided through LED lights on the shoe, which also serves to illuminate dark environments. Real-time adjustments can be made using the button located on the back of the device, allowing users to customize the range of detection up to four meters with a brief press. While walking in public, the makers recommend the continued use of a guide dog alongside the smart shoes.

IV RELATED WORK

In their study published in the International Journal of Advance Research in Science and Engineering (IJASE) in 2019, Ariba Khanam, Anuradha Dubey, and Bhabya Mishra introduced smart assistive shoes designed specifically for blind individuals, aiming to support them in their daily activities. These shoes are equipped with sensors that detect nearby obstacles and transmit corresponding messages in both audio and vibration formats to the wearer. The system relies on ultrasonic sensors to detect obstacles, with an Arduino microcontroller facilitating continuous monitoring and providing feedback through vibrations. The paper addresses the challenges faced by visually impaired individuals and proposes a solution in the form of these assistive shoes. Additionally, the authors suggest future enhancements such as incorporating image recognition capabilities using web cameras or NI cameras to identify objects and scan the surrounding environment for potential obstacles.

In a study conducted by Ziad O. AbuFaraj, Elie Jabbaur, Paul Ibrahim, and Anthony Ghaoui, published in the Institute of Electrical and Electronics Engineers in 2018, a prototype of rehabilitative shoes tailored for the blind was designed and developed. Each shoe is equipped with three pairs of ultrasonic transducers positioned along the toe cap to detect obstacles at various heights and ground irregularities such as pits and holes. Furthermore, the design considerations addressed factors like foot swing, ground level detection, stair negotiation, and other potential hindrances perceived as obstacles. Tactile feedback is provided by three miniature vibrating motors embedded within the shoe collar. The study involved intensive training sessions with individuals using the smart shoes, wherein each sensor was individually tested to trigger the corresponding tactile output.

This research was published in the International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE) in 2016, Shlesha Khursade, Malavika Karunan, Ibtisam Sayyad, and Saloni Mohanty explored the concept of smart shoes as a promising solution for enhancing safety and navigation for the visually impaired. They propose a wearable system that leverages common technology like Android mobile applications to provide directional guidance. Sensors integrated into the hardware detect obstacles, triggering vibrational cues for left and right turns along the path, while a buzzer alerts users to nearby obstacles. By utilizing Android applications, this innovative approach aims to enhance the navigation experience for visually impaired individuals, ensuring timely and effective obstacle detection within a predefined range.

In this study published in the International Journal of Engineering Science and Computing in 2019, Shanthi M, Madhu Meena M.K, Kadiravan R, and Kowsalya R.J present a novel concept of Li-Fi based smart shoes designed to aid visually impaired individuals in navigation using voice commands conveyed through light sources. The proposed system utilizes RFID readers to detect information stored on tags, which is then translated into Braille code by a control unit. Ultrasonic sensors are employed for obstacle detection, while IR sensors detect water on the path. The Li-Fi module emits LED light to transmit data to the shoe module, where a receiver converts the light signal into electrical signals, which are further processed into binary data recognized as audio signals. This innovative approach offers a unique method for navigation, providing real-time guidance to visually impaired individuals through voice commands conveyed via Li-Fi technology.

In their research published in the International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering in 2017, Saylee Begampure, Renuka Deshmukh, Sheetal Chotaliya, and Shubham Sirsat introduce a smart navigational system embedded within shoes, leveraging the Android operating system developed by Google for mobile devices. Power is supplied to the system through a battery, while Bluetooth connectivity enables the shoes to receive location coordinates from a smart phone's GPS settings. Synchronized with a smart phone app utilizing maps, the shoes provide vibrating cues to guide users on when and where to turn during navigation. Additionally, an IR sensor is integrated into the project for obstacle detection, triggering a buzzer when obstacles are detected on the path. Future enhancements may involve the incorporation of Bluetooth speakers to receive location coordinates directly from mobile phones using GPS technology.

V.METHODOLOGY

In our methodology, we established a connection between an ESP32 microcontroller and an ultrasonic sensor to detect obstacles by utilizing ultrasonic waves. The integration of a buzzer provides auditory alerts to visually impaired individuals when obstacles obstruct their path, potentially reducing the risk of accidents during walking. Additionally, piezoelectric sensors were employed to harness mechanical energy from footsteps, converting it into electrical energy. This serves as a backup power source for the system, enhancing its reliability and longevity.

In this smart shoe system, the ESP32 microcontroller plays a central role by interfacing with all sensors and components. Initially, the ultrasonic sensor detects obstacles and relays this information to the microcontroller, which then instructs the buzzer to emit sound and activates the vibrator to alert the user, mitigating potential risks. Additionally, piezoelectric sensors are utilized to harness energy generated during walking, serving as a backup power source for the device's battery. The microcontroller also incorporates a WiFi module, facilitating IoT functionalities such as step counting, GPS tracking, and distance monitoring, enhancing the overall functionality and utility of the system.

VI.HARDWARE USED:

- **ESP32 Microcontroller:**

The ESP32 is a cost-effective, energy-efficient microcontroller series featuring integrated Wi-Fi and dual-mode Bluetooth capabilities. Developed by Espressif Systems, it utilizes various microprocessor configurations including TensilicaXtensa LX6, Xtensa LX7, and single-core RISC-V. Incorporating built-in antenna switches, RF balun, power amplifiers, and other components, it offers enhanced functionality for IoT applications. Manufactured by TSMC using a 40 nm process, the ESP32 succeeds the ESP8266 microcontroller.

- **Ultrasonic Sensor:**

Ultrasonic sensors use ultrasonic sound waves to measure the distance between objects. It uses a transducer to send and receive these waves, and then it records echo patterns to determine how close something is. The transducer of the sensor is able to emit pulses and record echoes because it operates at frequencies that are higher than those that are audible to humans. Time intervals between pulse emission and echo reception are measured in order to determine distance. IoT ultrasonic sensors can be used for a variety of tasks, including fluid level monitoring, fluid identification, and item proximity detection. They are specifically made for the contactless detection of solid and liquid objects

Fig.1 Ultrasonic sensor

- **Buzzer**

A buzzer functions as an auditory signaling device, with variations including mechanical, electromechanical, and piezoelectric types. In this case, a 5V passive buzzer is utilized, typically employed for generating sound signals in applications like alarms, timers, and user input confirmation. Unlike automatic tone generation, the passive buzzer requires an alternating current (AC) signal to produce sound, with changes in the input signal dictating the emitted sound frequency. To operate the 5V buzzer, one pin is connected to the ground while the other connects to a microcontroller programmed to output a square wave or a timer IC.

Fig.2 5v Passive Buzzer

- **Vibrator**

A vibration motor, also known as an eccentric rotating mass (ERM) or vibratory motor, is a compact, coreless DC motor used to notify users of incoming signals solely through vibration, without sound. Operating at over 900 RPM with a power supply of 1.5V, this motor is commonly found in cell phones, handsets, pagers, and similar devices. It functions by spinning an intentionally unbalanced shaft, producing vibrations. Polarity is inconsequential, allowing the motor to rotate clockwise or counterclockwise. Primarily used for call notifications without audible alerts, these motors are lightweight, compact, and possess magnetic properties, ensuring consistent performance. They are available in two configurations: coin and cylinder models.

a. SOFTWARES USED:

- **Arduino IDE:**

The Arduino Software (IDE) is a user-friendly platform comprising a text editor, message area, console, toolbar, and menus for programming microcontrollers. Compatible with Mac, Windows, and Linux, it serves as a versatile tool suitable for both beginners and advanced users. Widely utilized by teachers, students, designers, architects, musicians, artists, and hobbyists, Arduino facilitates diverse applications ranging from scientific instrument creation to robotics and interactive prototypes. Its accessibility fosters learning and experimentation, enabling individuals of all ages and backgrounds to engage in tinkering and knowledge sharing within the Arduino community. While there are alternative microcontroller platforms available, Arduino stands out for its simplicity, offering distinct advantages for educational and amateur use.

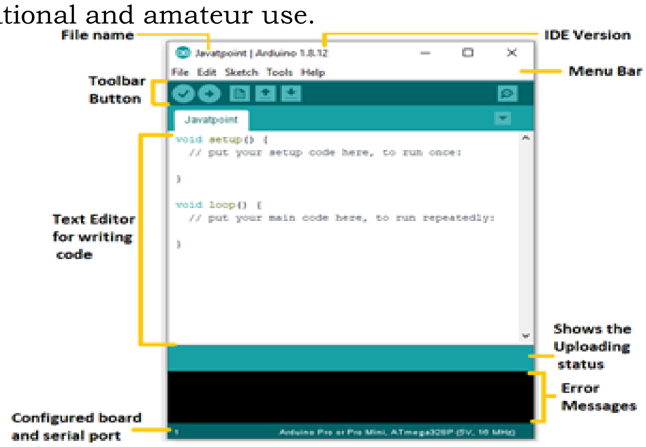

Fig.3 Arduino IDE Interface

V. RESULTS AND DISCUSSION

In this project, Arduino IDE software was utilized to program commands for the ESP32 microcontroller. Upon detecting an obstacle, the ultrasonic sensor sends a signal to the ESP32, which subsequently triggers the vibrator and buzzer to alert the user. Additionally, the piezoelectric sensor generates electricity while walking, serving as a backup power source, and charges the lithium battery. With its built-in Wi-Fi and Bluetooth modules, the ESP32 can establish connections with smar tphones, enhancing its versatility and potential applications. an overview of the applications of ambient sensors and systems integrated into the project. Following the successful coding implementation and testing phase, the following outcomes were observed: commanding the ESP32 microcontroller, establishing connections between the ultrasonic sensor, vibrator motor, and buzzer with the microcontroller, and attaching piezoelectric sensors to the shoe sole while connecting them to the battery. Screenshots showcasing the setup are provided above the figure for reference.

Fig.4 Final Prototype of the system

VII. CONCLUSIONS

In conclusion, our project utilizes ultrasonic sensors integrated into smart shoes to effectively detect obstacles in the path of visually impaired individuals. Upon detection, signals are swiftly transmitted to the ESP32 Microcontroller, which in turn activates the buzzer and vibrator to alert users, ensuring their safety while navigating. By harnessing a reliable source of light for communication, our system aims to enhance accessibility and independence for visually impaired individuals. Future endeavours will focus on optimizing system performance and alleviating user burden, ultimately striving for continued improvement and innovation in assistive technologies for the visually impaired.

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