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Smart Guiding Shoes - Advancing Navigation for the Visually Disabled

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ABSTRACT**:** The primary objective of this project is to design and implement a device to aid visually impaired individuals in navigating their surroundings with enhanced confidence and ease. The proposed device aims to alleviate some of the common challenges that visually impaired individuals face while walking. The project intends to mitigate the significant travel-related difficulties faced by visually impaired individuals, which arise due to their restricted ability to gather and interpret visual information. This lack of awareness about their surroundings makes it challenging to navigate both indoor and outdoor environments and increases their risk of accidents and injuries. "There are approximately 37 million people across the globe who are blind according the (WHO) World Health Organization [1]." And if talking about numbers of blind people in India, then "one out of every three blind people in world is Indian i.e., estimated 15 million blind people love in India [2]."
Thus, the project aims to develop an All-In-One device that would provide as a guidance to the blind people. The paper focusses on constructing a device for visually impaired (or blind) people that would support them to travel independently. The Technology introduced in the paper serves as a solution for visual impaired people that alerts them over obstacles coming between their ways, alerting for any fluid or moisture in the path and even tracking and sending the location of user and also other functionalities that make it fully smart.

Keywords— **Visually impaired, Smart shoes, Sensors, Guidance device, Obstacle detection, Fluid or water detection, Location tracking, Smart device, Assistive technology, Arduino, Blind Navigation system, wireless.**

I. INTRODUCTION

Every year a lot of visually impaired people go through accidents just because there was no one to assist them. But the major question is "do they really want to feel helpless living creatures roaming around the streets in need of assistance?" Well in this fast-forwarding world nobody wants to ask for help or offer help to the people in need. Especially for such people who are visually impaired or have low vision and do not like to ask for help or gain sympathy from others. For such people in need, we introduce a smart shoe, which not only gives them their independence but assistance too. The smart shoes will make them able to walk around different places by themselves. The sensor inbuilt in the shoes will work as their sense which they lost for some reason and give them a way to be free. The major benefits of this shoes will be a helping hand and it will also help in decreasing the rate of accidents of visually impaired people.
Blindness and visual impairment have a profound impact on individuals, depriving them of the ability to perform activities of daily living, including navigation and mobility. These disabilities have physiological, psychological, social, and economic outcomes that affect an individual's quality of life.

II. LITERATURE SURVEY

"Assistive technology for visually impaired people has been the subject of numerous studies [3]." Wearable devices such as smart glasses, smart gloves, and smart shoes have been developed in recent years to offer assistance. "While the white cane is a well-known technology for visually impaired individuals [4]", it has limitations that have prompted the development of newer technologies, such as guide dogs, "electronic travel aids [11]", and GPS-based navigation devices. "Electronic travel aids use ultrasonic or infrared sensors to detect obstacles [5]" and provide feedback to the user, while GPS-based navigation devices use satellite technology to offer location and navigation information.
To improve the accuracy and effectiveness of electronic travel aids, "Researchers have investigated various approaches, including the use of stereo vision and laser range finders [6]", as well as machine learning algorithms to enhance obstacle detection and classification. Additionally, wearable technologies like smart glasses have gained attention in recent years for their potential to aid visually impaired individuals.

This paper presents a proposal for creating an innovative smart navigation shoe that expands on previous research and development efforts in assistive technologies aimed at helping visually impaired individuals. Unlike previous studies, this proposed device offers an all-inclusive product that addresses the limitations encountered by visually impaired individuals in current technological solutions. The device includes a microcontroller, ultrasonic sensors, GPS module, GSM module, raindrop sensor, and mobile phone vibration motors that work together to provide real-time feedback about the user's surroundings and enable independent navigation. "Furthermore, the device also detects and provides feedback about any moisture or fluid material like mud or water through its raindrop sensor [7].

III. PROPOSED IDEA

By modifying the usage of existing technology and integrating it with shoes, we proposed an all-inclusive product, named "Smart Navigation Shoes [8]-[10]," which addresses the limitations of current technological solutions for visually impaired individuals by utilizing and modifying existing technology and integrating it with shoes.

IV. HARDWARE DESCRIPTION

The proposed idea comprises several hardware components, including:

1.1 Arduino Mega 2560:

"This microcontroller board is based on the ATmega2560 and comes equipped with a range of features, such as 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. To get started with the microcontroller, one needs to simply connect it to a computer using a USB cable or power it with an AC-to-DC adapter or battery [12]."

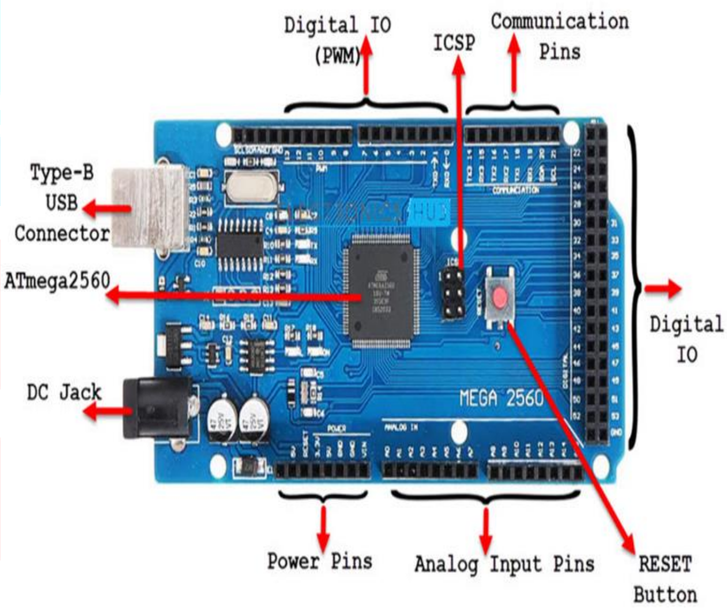


Fig 1. Arduino mega 2560

4.2 Ultrasonic sensors (HC-SR04):

"The HC-SR04 ultrasonic sensor is a widely used device for distance measurement in various applications, including security systems, automation, and robotics [13]." These sensors consist of two ultrasonic transducers - one serves as a transmitter that converts the electrical signal into ultrasonic sound pulses of 40 KHz, while the other acts as a receiver that listens for the transmitted pulses. The receiver produces an output pulse whose width corresponds to the distance of the object in front of it. With a non-contact range detection capability between 2 cm and 400 cm and an accuracy of 3 mm, these sensors can operate on 5 volts and be directly connected to an Arduino or any other 5V logic microcontroller. For this project, we utilized two ultrasonic sensors - one for nearby objects (<50 cm) and the other for distant objects (<100 cm).

Fig 2. ultrasonic sensor (hc-sr04)

4.3 Piezo Buzzer:

These are simple devices that generate basic beeps and tones using a piezo crystal, a special material that changes shape when voltage is applied to it. The buzzer generates sound by changing shape quickly, producing different sound with different frequencies.


Fig 3. piezo buzzer

4.4 NEO-6M GPS module:

To acquire the user's location data or GPS data, we utilized the NEO-6M GPS module [14]. This module includes the u-blox NEO-6M GPS engine, which is known for its high sensitivity for indoor applications. The module features one MS621FE-compatible rechargeable battery for backup and EEPROM for storing configuration settings. It operates optimally with a DC input in the 3.3- to 5-V range and can track up to 22 satellites over 50 channels, providing the industry's highest level of tracking sensitivity. The patch antenna is the most commonly used antenna type with this module and requires a direct line of sight with as many visible satellites as possible to ensure uninterrupted reception. Furthermore, the EEPROM and battery work in tandem to maintain the Battery Backed RAM (BBR), which contains clock data, latest position data (GNSS orbit data), and module configuration.


Fig 4.1 patch antenna

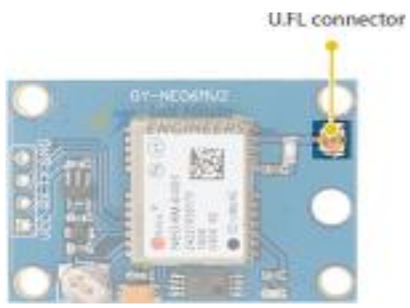


Fig 4.2 gps module

4.5 Mobile phone vibration motors:

These motors are small and shaftless, with no exposed moving parts. They can run clockwise or counterclockwise and have a vibration amplitude of 0.75g and draw approximately 60mA when 3V is applied to their leads. One of the motors is used for alerting nearby obstacles, and the other is for far away obstacles. In this project two mobile phone vibration motors are used one for alerting to distant obstacles and second for nearby obstacles.

Fig 4.vibrator motor

4.6 Rain drop Sensor Module: In order to detect any fluid or moisture in the path of the user, the project utilizes a specialized module consisting of a rain board and a control module [15]. The rain board is responsible for detecting the presence of rain, while the control module takes the analog input and converts it into a digital signal for further processing. This module is situated at the front part of the shoes to ensure accurate detection of any fluid or moisture present in the user's path.

Fig 5.water sensor

4.7 SIM900A GSM Module:

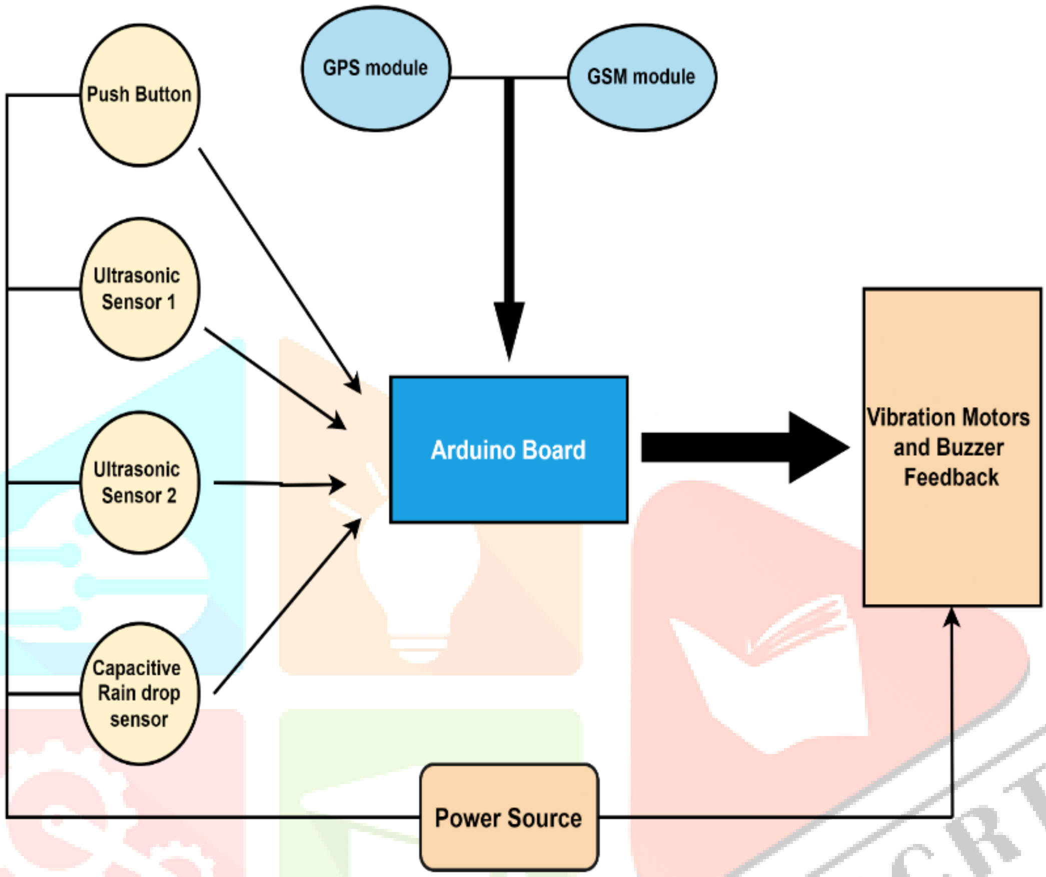
This module is the cheapest and smallest medium for communication through GPS/GPRS and uses a mobile SIM, making it common in Arduino and microcontrollers. It operates at a frequency of EGSM900 and DCSI800 and requires a power input of 3.4V - 4.5V. It also has antenna support, serial debug port, and audio input/output. In this project, the GSM module is used to send the user's location coordinates to their family contacts in case of an emergency [16-18].

Fig 6.gsm module

4.8 Battery:

A lithium-ion rechargeable battery is used as the power source for the project, which can deliver a minimum output of 5V and 2A.

V. Block Diagram:

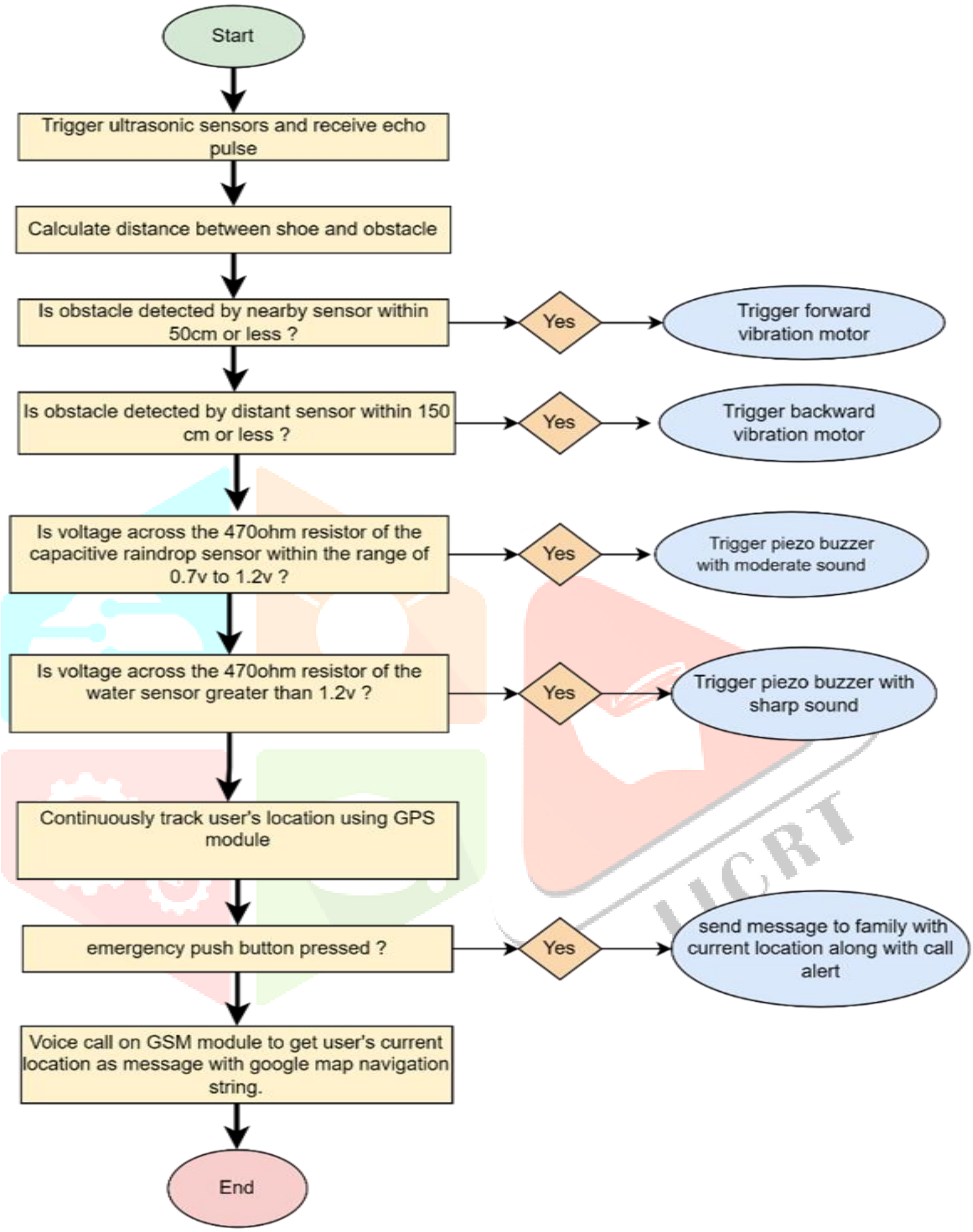


VI. ALGORITHM

The functioning of this project involves several general steps, which are outlined below:

1. Send a burst of ultrasonic pulse from both ultrasonic sensors to detect the obstacle in the path by setting the trigger pin of the ultrasonic sensor high.
2. Receive the echo pulse using the Echo pin of the ultrasonic sensor.
3. Calculate the time duration between the transmitted pulse and echo pulse to determine the distance between the shoe and obstacle, and hence calculate the distance between the sensor and obstacle.
4. Trigger the forward vibrating motor if the obstacle detected by the nearby sensor is within the distance of 50cm or less.
5. Trigger the sideward vibrating motor if the obstacle detected by the distant sensor is within the distance of 100cm or less.
6. Trigger the piezo buzzer with a moderate sound if the voltage across the 470ohm resistor of the voltage dividing circuit of the capacitive raindrop sensor is found within the range of 0.7v to1.2v, indicating the presence of watery mud in the blind person's path.
7. Trigger the piezo buzzer with a sharp sound if the voltage across the 470ohm resistor of the voltage dividing circuit of the water sensor is found to be greater than 1.2v, indicating the presence of water in the blind person's path.
8. Continuously track the exact location of the user using the GPS module, and on pressing the emergency button, send a message containing the current location of the user in latitude and longitude to some of his/her contacts using the SIM900A GSM module.
9. In addition, user’s family members or his/her closed ones who wants to know the location of the user can simply voice call on the number in the GSM module, and the call will be hung up while the location of the user, along with a call back alert, will be sent by the GSM module.

VII. ALGORITHM FLOW CHART



VIII. ADVANTAGES

- Automated detection of obstacles.
- Provides guidance for the correct path.
- Easy to operate.
- Reduces the risk of accidents for visually impaired individuals.
- Suitable for use in both indoor and outdoor environments.
- Automatic rerouting and alerts for unexpected changes.

- Dependable technology that provides voice feedback based on surroundings.
- GPS tracker sends the blind person's coordinates to a mobile device, which can be used to track their position on Google Maps.
- User-friendly system that is easy to understand.
- Navigation assistance provided while travelling.
- Loved ones of the visually impaired person can easily track their location by calling a specific number, without needing to worry about their whereabouts.

IX. PROTOTYPE

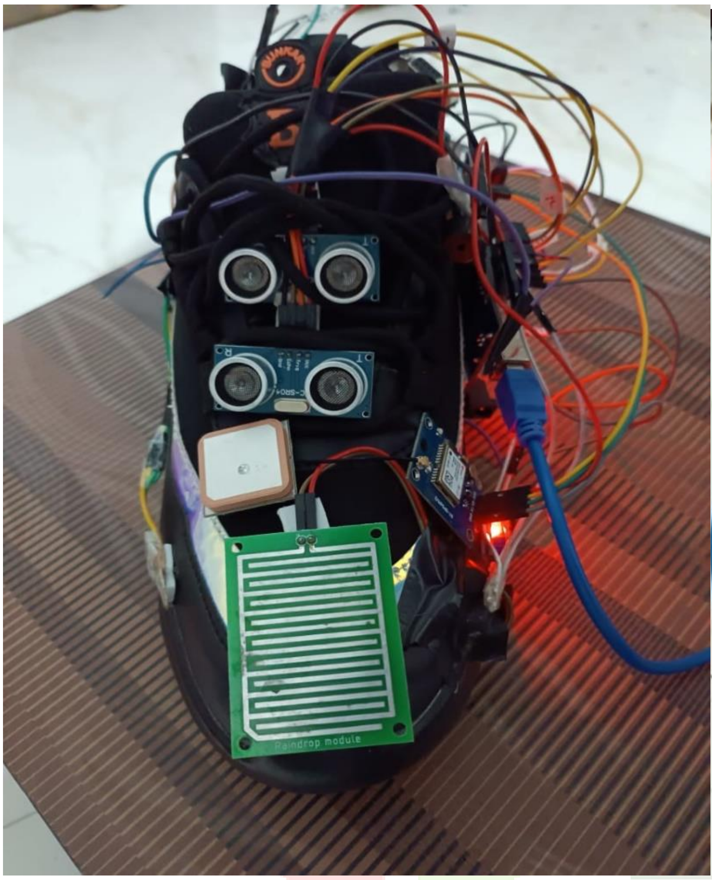


fig 9.1 front view

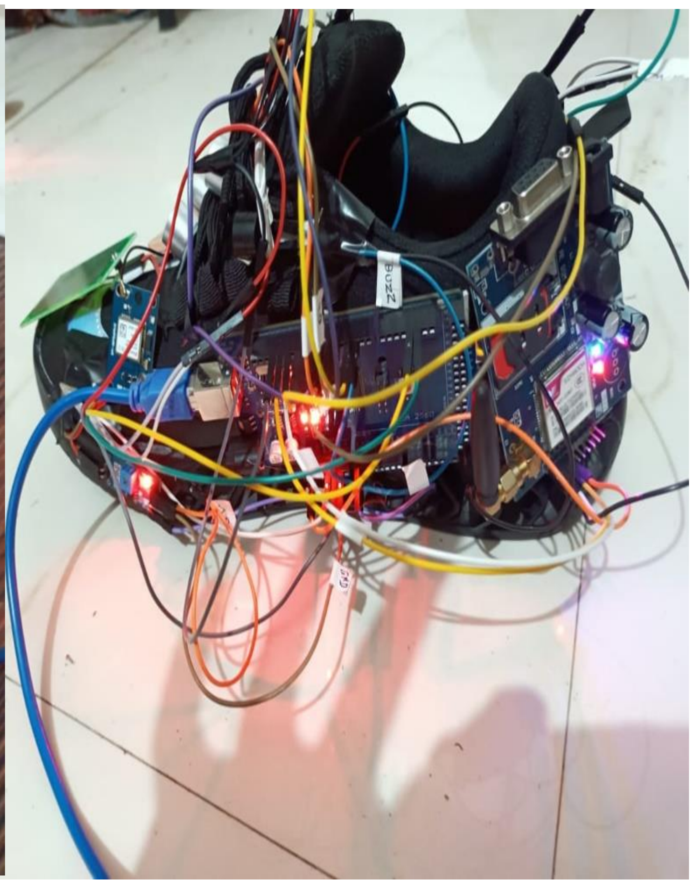


fig 9.2 side view

X. CONCLUSION

The proposed project introduces a novel design and architecture of Smart Navigation Shoes to aid visually impaired individuals in navigating through different terrains and obstacles. The system has the potential to provide a low-cost solution to millions of blind people worldwide. The Smart Navigation Shoes enable visually impaired individuals to become more self-reliant and reduce accidents caused by falling into pits or stumbling over uneven surfaces due to construction or other reasons. Future work will focus on improving the system's performance and reducing the user's workload by incorporating additional sensors to enhance decision-making capabilities, making it suitable for various applications.

XI. FUTURE SCOPE

The future work for this project will concentrate on enhancing its performance by utilizing more advanced sensors such as the DYP-ME007Y ultrasonic sensor, u-blox ZED-F9P GPS module, Telit GL865 GSM module, Gravity Analog Capacitive Soil Moisture Sensor, Teensy 4.1 board, and ribbon cable. With these sensors, the device can become more compact, lightweight, and accurate.

The use of a Wi-Fi module in the device will make it fully intelligent by enabling it to connect to the internet and access information about the user's surroundings. This could include real-time traffic updates or nearby points of interest, improving the accuracy of the navigation experience. Additionally, a Wi-Fi module could allow remote control and monitoring of the device, providing assistance to the visually impaired individual from afar.

To further improve the functionality of the device, a smartphone application can be developed. The application can offer voice commands, an audio map with instructions, and the option to customize the device settings. The application can communicate with the device through Bluetooth or Wi-Fi, allowing the user to have more control over the device and receive additional information about their surroundings.

To make the shoe more self-sustaining, piezoelectric sensor layers can be integrated into the shoe sole. These sensors generate electricity when pressure is applied, such as when the wearer walks, and can be used to charge the battery of the Smart Navigation Shoes. This reduces the need for frequent charging and makes the shoes more practical for everyday use.

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