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Embedded Smart Shoes for The Visually Impaired

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Abstract: Embedded smart shoes represent a burgeoning field at the intersection of wearable technology, biomechanics, and human-computer interaction. These intelligent footwear systems integrate various sensors, microcontrollers, and communication modules within the shoe's architecture, enabling real-time data acquisition, analysis, and interaction with external devices or systems. This paper reviews the usage of embedded shoes for persons with disabilities such as visual impairment and its applications. We examine how embedded smart shoes are a great support to blind people in their movement. Additionally, we discuss the challenges associated with embedded smart shoe development, including power management, sensor accuracy, data privacy, and user acceptance. Through an interdisciplinary lens, this review aims to inspire future research and innovation in embedded smart shoes, fostering advancements that enhance both human-computer interaction experiences and biomechanical understanding.

Keywords: Embedded Smart Shoes, Visually Impaired, Obstacle detection, Location tracking.

INTRODUCTION

Embedded Smart Shoes by virtue of their name itself represent the combination of daily necessities and smart connectivity. The concept of Smart Shoes was used as early as 1989 by the infamous shoe brand Nike. These shoes were used in gait analysis and when synced to an app with the highest level of security and encryption in mind, the colors of the shoes can be changed as well at any time at the touch of a phone. These smart shoes are also a great innovation in the field of healthcare and fitness [1,2].

In a world where mobility is often taken for granted, the visually impaired face unique challenges navigating their surroundings. Everyday tasks like crossing the street or maneuvering through crowded spaces can present daunting obstacles. However, advancements in technology are offering promising solutions to enhance independence and safety for the blind community. Embedded smart shoes represent a groundbreaking innovation in this realm, providing real-time feedback and assistance to users as they move through their environment.[3]

Embedded smart shoes are a fusion of cutting-edge technology and practical design, engineered to serve as a reliable companion for individuals with visual impairments. Equipped with an array of sensors, these shoes are capable of detecting obstacles, changes in terrain, and other potential hazards in the user's path. Through seamless integration with a smartphone or wearable device, the shoes utilize advanced algorithms to interpret sensor data and provide intuitive feedback to the wearer. [4,5]

The primary objective of embedded smart shoes is to empower the blind with greater confidence and autonomy in their daily travels. By leveraging features such as obstacle detection, these shoes offer real-time navigation assistance, guiding users along safe and efficient routes. Whether navigating busy streets, exploring unfamiliar environments, or simply navigating indoor spaces, the shoes serve as a trusted companion, enhancing the user's spatial awareness and facilitating smooth navigation. Along with obstacle detection, these shoes offer services such as tracking the user and alerts in case of emergency through the GPS to their respective guardians or handlers. [6,7,8,9]

Moreover, embedded smart shoes are designed with versatility and comfort in mind, ensuring that users can incorporate them seamlessly into their everyday routines. Whether walking, running, or standing, the shoes adapt to various activities and environments, providing consistent support and assistance throughout the day. [10,11,12]

In this era of technological innovation, embedded smart shoes represent a significant leap forward in accessibility and inclusivity for the visually impaired. By harnessing the power of sensors, connectivity, and intelligent algorithms,

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these shoes are transforming the way individuals navigate the world, opening up new possibilities for independence and exploration. As we delve deeper into the capabilities of embedded smart shoes, we uncover not just a technological marvel, but a symbol of empowerment and freedom for the blind community. [14,15]

PROBLEM STATEMENT

The presented project tackles the challenges that a visually impaired individual faces in their day-to-day lives. One of the foremost issues addressed is the obstacle detection which is very much needed in this case. Secondly, the project also highlights the use of GPS in the lives of visually impaired individuals. Along with obstacle detection, it is equally important for the handler/guardian of the visually impaired individual to track the location of the individual at all times.

The older version of Embedded Smart Shoes for the blind showcased problems such as a noise made every time an obstacle was detected. In some cases, if the ultrasonic sensor was situated on the right shoe, the left shoe was treated as an obstacle.

This innovative approach aims to provide the user with a less noisy experience and enables the users to get to know the direction of the obstacle. By combining technological solutions with daily necessities, this project seeks to significantly improve user safety and security.

METHODOLOGY

Left Shoe

The left shoe is very simple in design which contains very few components and very little functionality. The design contains the Ultrasonic Sensor (HC-SR04) module to calculate the distance from shoe to the obstacle. In order to provide the horizontal field view at the ground level the ultrasonic sensor is mounted on the servo motor. The DC vibration motor is also placed to signal the user when the detections are within the field of impact. These signals are varied according to the direction of the obstacle. The Microcontroller used is Arduino, which is used to control the circuitry on the shoe. The piezoelectric materials along with the bridge circuit is used to generate the energy while the user is walking. To power the microcontroller board the batteries are incorporated.

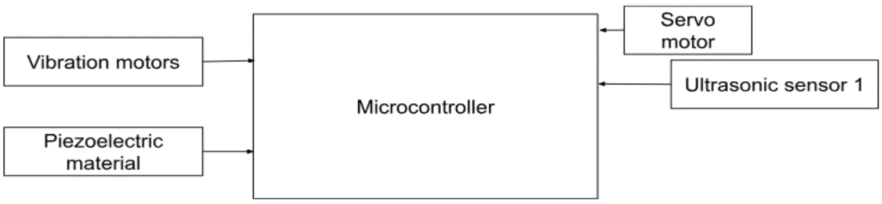

Figure 2. Block Diagram of Left Shoe

The ultrasonic sensor mounted on the servo motor is initially aligned to 0^0 to provide the left view to the ultrasonic sensor. Then the servo motor is rotated by the steps of 10^0 to cover the field at the ground level i.e from 0^0 to 180^0, so the setup of the ultrasonic sensor with servo motor will give the ground level obstacle detection. If the obstacle is detected on the left side (0^0 to 90^0), the vibration motor is turned on for 1 second. If the obstacle is detected on the right side (90^0 to 180^0) the vibration motor is turned on for 2 seconds. The piezoelectric materials are used to generate the electrical energy from the pressure applied while walking. The bridge circuit is used to increase the efficiency of the generated energy. This generated energy is stored in the battery and is used to power the other electronic components that are present on the shoe.

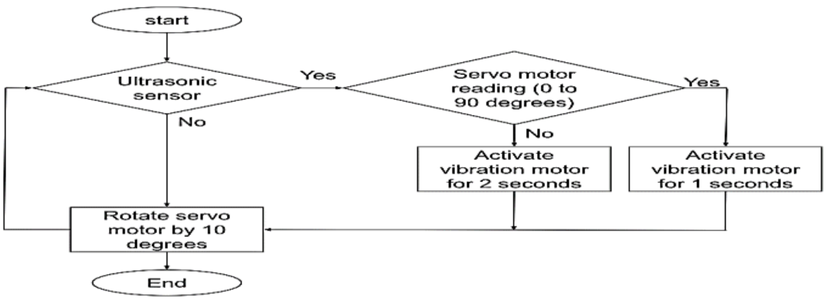

Figure 1. Flow Chart for Left Shoe

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Right Shoe

The right shoe consists of a complex circuit with many modules placed on it with a complex working. All the components which are present on the left shoe are also present on the right shoe namely the ultrasonic sensor, servo motor, DC vibration motor and piezoelectric materials along with the bridge circuit. In addition, other devices are also used on this shoe. The additional components placed like the GPS module are used to get the location information of the person. GSM module is embedded in order to get the mobile network connectivity to the microcontroller. The sim is placed in the GSM module. The panic button is available for providing safety to the user. The power turn on/off switch is provided to limit the power consumption from the batteries.

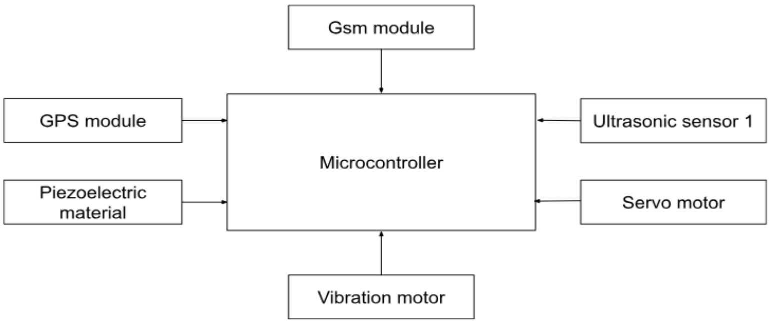
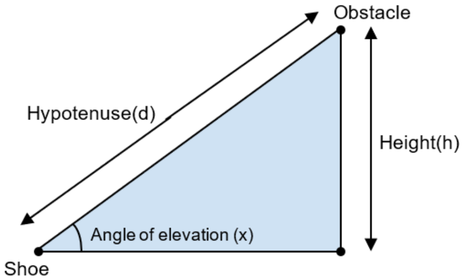


Figure 3. Block Diagram of Right Shoe

The ultrasonic sensor and servo motor alignment is a bit different on this shoe in order to give the view in terms of elevation. The initial position is defined to ground level with the elevation of 0^0. The elevation is raised with the rotation of blades of the servo motor in steps of 5^0. The elevation of the obstacle is detected based on the reading from both the sensors. If we assume a right angled triangle formed by sensor obstacle and ground. The distance measured by the ultrasonic sensor is considered as the hypotenuse of the triangle, the servo motor reading is the elevation angle, hence with help of these two we will get the height at which the obstacle is present.



From the above parameters height is calculated as
=> sin(x) = height(h)/hypotenuse(d)
=> sin(x) = h/d
=> h = d*sin(x)

If the calculated height is below 6 feet and above 3 feet, then the alert signal for 1 second is given. If it is in range of 0 to 3 feet, a signal of 2 seconds is given with the help of a DC vibration motor. In case of any emergency the panic button is pressed, and at that instance the location coordinates are loaded to the microcontroller. The alert message with the location coordinates is sent to the specified caretaker. The piezoelectric materials along with the bridge circuit is used to generate the energy while the user is walking. To power the microcontroller board the batteries are incorporated.

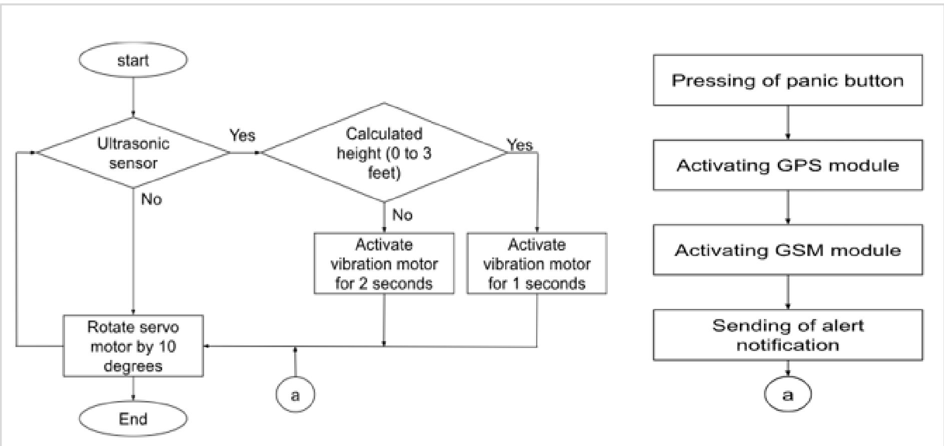


Figure 4. Flow Chart for Right Shoe

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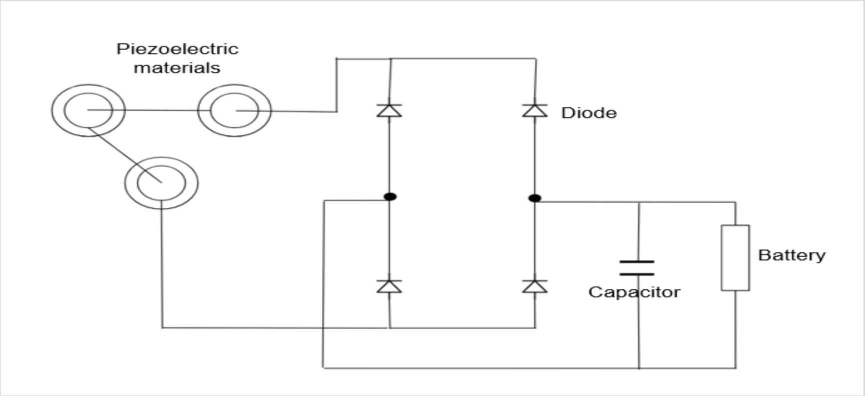

Figure 5. Bridge circuit with piezoelectric material

Piezoelectric materials can convert mechanical vibrations or movements into electrical energy by virtue of the piezoelectric effect, where deformation induces electric charges within the material. This principle is leveraged in energy harvesting systems, where piezoelectric elements are integrated into structures experiencing regular vibrations (like bridges or machinery) to capture mechanical energy and convert it into electricity. By connecting the piezoelectric material to a circuit with rectifiers for converting AC to DC and storage components like capacitors or batteries, the harvested electrical energy can be stored or used to power small electronic devices. The efficiency of piezoelectric energy harvesting depends on factors such as material properties, applied mechanical stimuli, and circuit design, making it a promising renewable energy solution for capturing ambient mechanical energy.

RESULTS

Our project aims in developing the Embedded Smart Shoe for the Blind community which include improved safety, increased independence, enhanced navigation capabilities, user-friendly interface, customization options, durability, and seamless integration with existing assistive technologies. These outcomes collectively contribute to enhancing the mobility and quality of life of individuals with visual impairments.

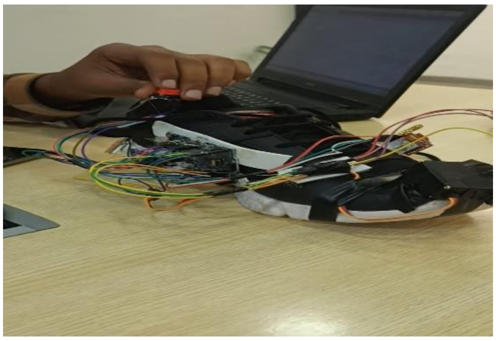

Figure 7. Left Shoe

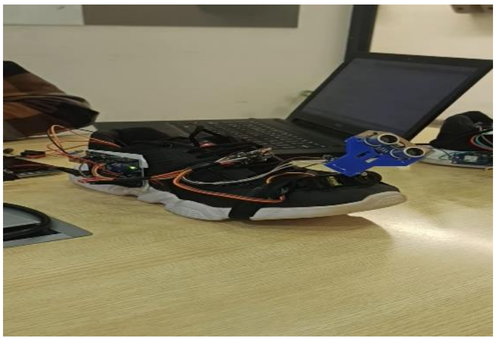

Figure 8. Right Shoe

CONCLUSION

The Embedded Smart Shoe developed with the help of advanced sensor technology and feedback mechanisms offers tangible benefits in terms of safety, independence and improved quality of life for visually impaired people. The Smart Shoe provides immediate benefits for users and also holds promise for societal impact.

The Embedded Smart Shoe which is designed for blind people addresses some of the challenges faced by the blind community in navigating in unfamiliar environments safely. The Ultrasonic sensors and pressure sensors work together to detect obstacles, changes in terrain and the user's movement providing valuable data for navigation.

The Arduino enabled us to process sensor data and execute control algorithms in real time. This allowed for rapid decision making and seamless interaction between the shoe and the user.

In conclusion, the Embedded Smart Shoe for the Blind community represents not only a technological achievement but also a testament to the transformative power of innovation in improving the lives of individuals with visual impairments. As we embrace the possibilities offered by assistive technology, as we move closer

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to realizing a future where disability is not a barrier to participation and inclusion.

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