Innovative Wearable Technology for Visually Impaired

Nurhafiza Azizan[1*], *Baseemah* Mat Jalaluddin[1], *Emilia Annisha* Shaffie[1], *Diyya Hidayah* Abdul Rahman[1], *Mohd Rizal* Manan[1], *Nur Irwany* Ahmad[1,2], and *Ahmad* Zaidi Abdullah[1]

[1]Faculty of Electrical Engineering & Technology, Universiti Malaysia Perlis, Pauh Putra Campus 02600 Arau, Perlis, Malaysia.
[2]College of Engineering (COE), Universiti Tenaga Nasional (@ The Energy University), Jalan IKRAM-UniTEN, Kajang, Selangor, Malaysia.

Abstract. In Malaysia, the prevalence of blindness for all ages is 0.2%, and low vision is 2.44% (based on the National Eye Survey, 1996). Vision impairment severely impacts the quality of their lives and can contribute to social isolation and difficulty walking. Therefore, the invention of Innovative Wearable Technology for Visually Impaired People is important for helping them navigate with speed and confidence by detecting nearby obstacles using ultrasonic waves and notifying them with the speaker, MP3 player, and vibration. The preceding technology encountered several technical challenges that hindered its optimal functionality. The primary issue revolved around the use of the Arduino Uno, which proved to be prohibitively expensive and impractical for integration into a wearable device due to its cumbersome size and restricted mobility. This rendered the previous solution less feasible for assisting visually impaired individuals who require a compact and efficient navigation aid. Another significant limitation pertained to the simultaneous employment of a buzzer and a motor as outputs, leading to potential confusion for users. The concurrent activation of these outputs might have caused difficulties in interpretation and user discomfort, undermining the device's overall effectiveness in aiding visually impaired individuals during their navigation endeavors. Considering these challenges, the development of Innovative Wearable Technology for Visually Impaired People seeks to overcome these drawbacks by introducing a more cost-effective and user-friendly solution. Therefore, this paper proposes Innovative Wearable Technology for Visually Impaired People, which aims to address the shortcomings of existing aids and provide enhanced assistance to the visually impaired community.

1 Introduction

According to data provided by the World Health Organization (WHO), an estimated 39 million people worldwide suffer from blindness, leading to various challenges in their daily

* Corresponding author: hafizaazizan@unimap.edu.my

lives [1]. For years, visually impaired individuals have relied on the traditional cane as an effective but limited means of navigation. An alternative option is to use guide animals, such as dogs, which can be prohibitively expensive [2][3]. The existing traditional stick used by visually impaired people falls short of meeting the demands of the modern world. A previous attempt at employing the Arduino Uno faced technical difficulties. The Arduino Uno's high cost and impracticality for use in a wearable device, due to its size and limited mobility, presented significant drawbacks [4]. Moreover, attaching an Arduino to a wooden stick could lead to potential damage and increased weight, making it cumbersome for users to carry. Mastering its correct usage would require considerable practice. A previous wearable wristwatch design also had its limitations, with a bulky box housing essential component, adding weight to the user's wrist [5]. Additionally, the WTV020M01 sound module used in another attempt only converted Mp3 audio to WAV and AD4 formats, necessitating the use of additional conversion software for the original MP3 audio in the SD card file [6]. Furthermore, employing both a buzzer and a motor as simultaneous outputs presented constraints and potential confusion for users [7].

P. Pai *et al* [8] have successfully developed an advanced smart stick catered to aid individuals with visual impairments in navigating their surroundings. The primary function of this innovative device is to detect obstacles using an amalgamation of infrared, ultrasonic, and water sensors, effectively identifying impediments within approximately 3 meters. Complementing this obstacle detection system, the smart stick incorporates both GPS and GSM modules. The GPS module provides precise positioning and navigation assistance, while the GSM module plays a vital role in issuing timely notifications to the user in the face of potential threats [8]. M.S Farooq *et al.* [9] have developed a sophisticated smart stick that incorporates Internet of Things (IoT) systems to address the obstacle recognition needs of individuals with impairments [9]. However, despite its remarkable functionalities, one drawback of this smart stick design is its non-foldable nature, which could present challenges regarding storage and portability for users.

Numerous walking aids with enhanced obstacle-detection capabilities and state-of-the-art navigation systems have been created to cater to the needs of visually impaired individuals [10]–[12]. C.M Yang *et al.* [13] have designed obstacle detection shoes for visually impaired people, which can detect obstacles based on foot angle. The obstacle-detection shoes comprised a combination of infrared sensors, six-axis sensors, buzzers, and battery packs. Likewise, M.S Kamaruddin *et al.* [12] have designed a smart assistive shoe integrated with IoT technology. These shoes are equipped with ultrasonic sensors and vibration motors, effectively alerting users about potential obstacles [12]. However, it does not elaborate on the overall effectiveness and efficiency of these walking aids in real-world scenarios, nor does it compare them with existing solutions.

Hence, the primary objective of this project is to create an innovative wearable technology that addresses these shortcomings, enabling visually impaired individuals to move freely and confidently. The focus lies in designing and simulating the circuit of this technology for visually impaired people using Proteus and Fritzing software. Through meticulous design and advanced software simulations, the proposed wearable technology has the potential to significantly improve the lives of those affected by visual impairments and disabilities, promoting inclusivity and empowerment in today's fast-paced world.

2 Methodology

2.1 Formatting *Design concept*

The depiction in Figure 3 illustrates the operational flow of the Innovative Wearable Technology for Visually Impaired People, which relies on the principles of ultrasonic waves. The central component of the system is the Arduino, which is responsible for programming and controlling the entire setup. The ultrasonic sensor receives the function from Arduino and automatically emits ultrasonic waves. When the emitted ultrasonic waves hit an obstacle and are reflected, the ultrasonic sensor detects the obstacle within a range of up to 100 cm. Subsequently, the system activates the speaker, MP3 player, and motor. To facilitate distance-specific alerts, five mp3 sound recording files are utilized, corresponding to detection distances ranging from 2 cm to 100 cm. Each recording file is allocated to a specific distance range, such as 2 - 20 cm, 21 - 40 cm, 41 - 60 cm, 61 - 80 cm, and 81 - 100 cm, and is associated with a designated MP3 player. For instance, if the detected distance falls within the range of 2 cm – 20 cm, the recording file "0001.mp3" from the memory SD card's mp3 folder will be played, delivering the message "There are people in front; the distance is 2 cm to 20 cm." The activation of the motor serves as an attention-drawing mechanism when the user approaches an obstacle, prompting them to either stop or take precautionary measures to avoid it. This concept is applicable to other distance ranges as well, and as a result, there are five mp3 recordings, namely 0001.mp3 to 0005.mp3, saved in the SD card's mp3 folder. To ensure clarity and formality in the voice recordings, Google Translate was employed, and the recordings were saved in Mp3 format for ease of reading by the system. Slide switches are utilized to toggle the system between open (off) and closed (on) positions, facilitating continuous operation of the process. In this manner, the system functions repetitively to assist visually impaired individuals in navigating their surroundings effectively.

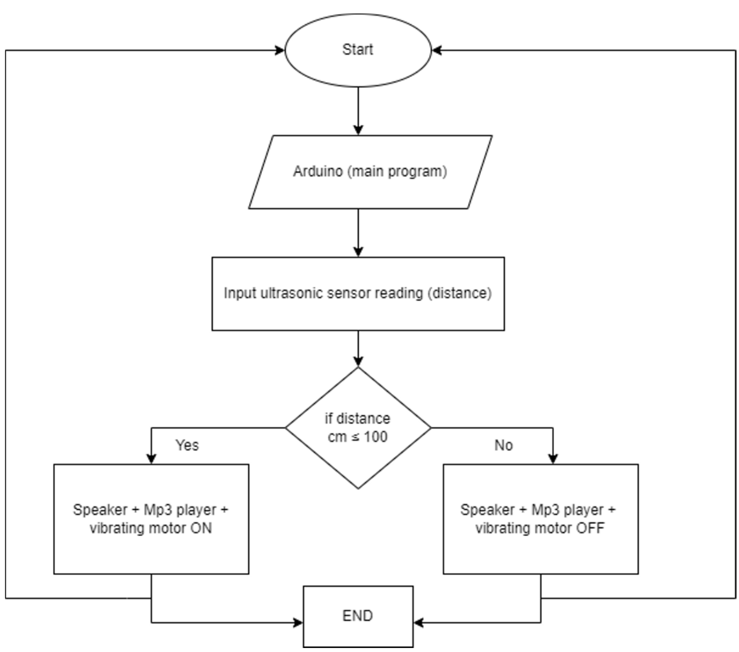


Fig. 1. Flow chart of the system

https://doi.org/10.1051/e3sconf/202457001007

The project incorporates a single glove module designed to be worn on the user's right hand. The module comprises a soldered-together donut board, an Arduino Nano, an Ultrasonic sensor, a speaker, an MP3 player, and a motor. Figure 4 illustrates the user wearing the glove module on their right hand. The detection area for obstacles is indicated by the waves transmitted from the user's right hand. Notably, this project harnesses Haptic technology, which enables the creation of a tactile experience through the application of forces, vibrations, or motions to the user. The hand, being highly sensitive and well-suited for haptic technology, emerges as the most appropriate body part for implementing this technology in the project. By utilizing the glove module in this manner, the system aims to enhance the user's tactile perception, contributing to more effective obstacle detection and navigation for visually impaired individuals. M. Dragusanu et al. [14] reported that the hand is one of the primary interfaces connecting humans and the surrounding environment, and it is also one of the main targets of haptics technology development. Most of the haptic devices for tactile stimuli are located on the fingers or on the wrist, while fewer are developed specifically for the palm [14]. The description provided for Figure 5 clarifies the movements of the user's right hand, detailing the biomechanical actions of the carpus. Specifically, it highlights the palmar flexion/dorsiflexion (LEFT) and radial abduction/ulnar adduction (RIGHT) movements, which are intrinsic to the primary hand's biomechanical structure. The wearable system, intended for blind individuals, involves the user wearing the device and directing the Ultrasonic sensor to perform precise obstacle detection, as demonstrated in Figure 5. By aligning the sensor in accordance with the depicted movements, visually impaired users can effectively utilize the system to navigate their surroundings, ensuring optimal obstacle detection and avoidance.

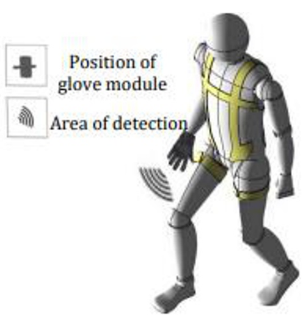


Fig. 2. Image of the user wearing the hand glove on their body

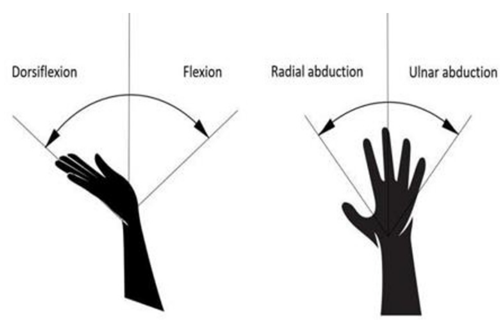


Fig. 3. Movements of primary module (*LEFT) and (RIGHT) [14].*

2.2 Software Development

Figures 4 and 5 show the simulation circuit design of the Innovative Wearable Technology for Visually Impaired People, meticulously created using Proteus and Fritzing Software. This comprehensive circuit represents the entirety of the functional components proposed for this project. To ensure seamless implementation in real-world scenarios, the system is initially simulated on a breadboard before being soldered onto a donut board, a precautionary measure aimed at preventing installation failures. In Figure 6, variable resistors serve as a crucial user interface, allowing users to interact with the device effectively. The integration of these resistors leverages a valuable Proteus feature, effectively mimicking the serial connectivity employed in embedded systems. The incorporation of this feature enhances the device's

 https://doi.org/10.1051/e3sconf/202457001007

versatility and usability, significantly contributing to its user-friendliness. This project further incorporates a virtual terminal to display the measured distance of obstacles detected by the ultrasonic sensor. This feature provides users with real-time feedback, enhancing their situational awareness and navigation experience. Additionally, an oscilloscope plays a central role in this project, graphing the electrical signal's variation over time. By generating a two-dimensional graph with time on the x-axis and voltage on the y-axis, the oscilloscope allows for precise analysis of the speaker and motor outputs. The yellow lines on the graph indicate the speaker’s output, while the blue lines represent the motor's output. By interpreting the oscilloscope waveform, essential parameters such as frequency, duty cycle, and voltage can be accurately determined. The variable resistors utilized in the simulation are a specific type of resistor equipped with the capability to modify the resistance measurement. These resistors play a crucial role in denoting the distance of obstacles detected by the device, significantly contributing to its obstacle detection efficiency.

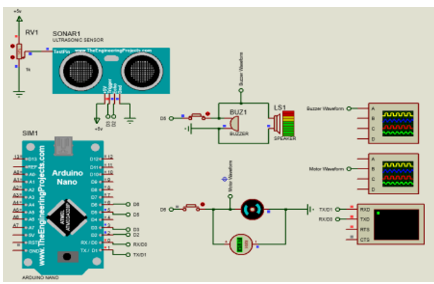


Fig. 4. Simulation circuit design using Proteus Software

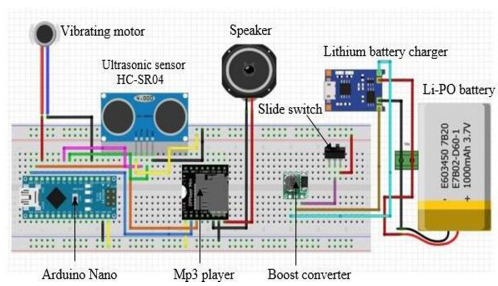


Fig. 5. Simulation circuit design using Fritzing Software

2.3 Hardware development

Figure 6 clarifies the arrangement of the circuit on a donut board. The battery, vibrating motor, and speaker are connected with long generic wires to facilitate easy attachment to the top of the glove. Conversely, the components soldered to the donut board are affixed to the palm of the glove. This configuration allows for well-organized and functional circuit integration. Figure 7 shows the prototype of the Innovative Wearable Technology for the Visually Impaired, displaying the entire set of components attached to the glove. This comprehensive setup brings together all the essential elements of the wearable system, demonstrating its practicality and potential to aid visually impaired individuals in navigating their surroundings effectively.

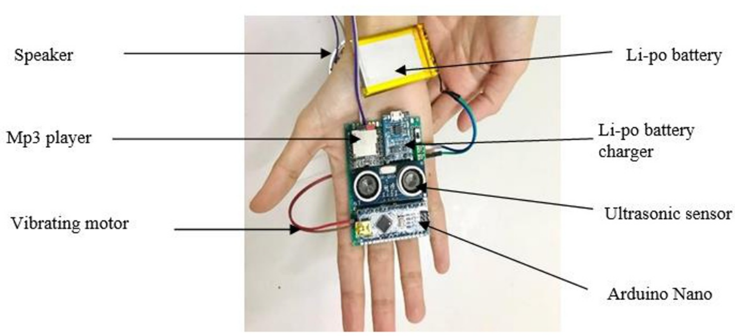
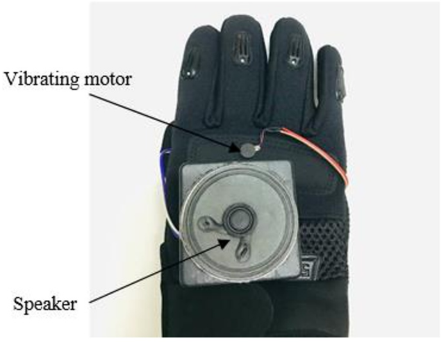
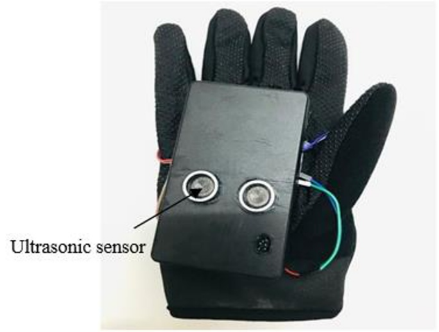


Fig. 6. Circuit implementation on a donut board





(a) (b)

Fig. 7. Prototype of the proposed system. (a) Top of the glove and (b) the palm of the glove

Figure 8 illustrates the appropriate application of the wearable system for both outdoor and indoor usage. Users are advised to follow a few essential steps when utilizing this system. To begin, the user should wear the glove on their right hand and switch it to the ON position using the slide switch. For precise sensor positioning, users must elevate their hand to chest level, ensuring that the Ultrasonic sensor is correctly oriented from the right, front, left, and bottom perspectives. The sensor's field of vision can extend up to a maximum of 15°, as shown. Upon detecting any obstacle, the system will activate the recorded voice message and engage the vibration motor, providing valuable assistance to the visually impaired in avoiding the obstacle and raising awareness of its presence. These functionalities collectively work to enhance the user's safety and mobility, making it a valuable aid for those with visual impairments in various environments and scenarios. The basic guidelines for assistive guiding tools are given by the National Research Council for ETAs [15]. The guidelines indicate the minimum requirements to be fulfilled by any guiding tools for blinds are listed below:

i. Detection of obstacles in the travel path from ground level to head height for the full body width.
ii. Travel surface information, including textures and discontinuities.
iii. Detection of objects bordering the travel path for shore lining and projection.

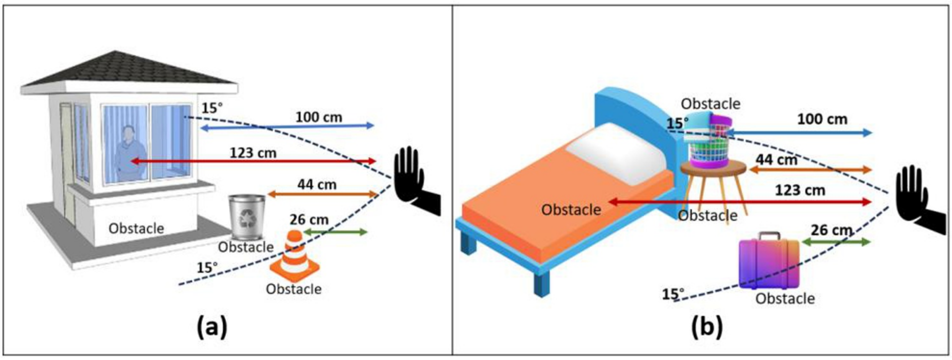


Fig. 8. (a) Outdoor and (b) indoor testing illustrations for obstacles 26 cm, 44 cm, and 123 cm.

3 Result and Discussion

3.1 Project performance based on outdoor and indoor obstacles

Innovative Wearable Technology for the Visually Impaired People underwent real-world testing in both outdoor and indoor settings as part of the design and development evaluation. Different types of obstacles and varying distances were selected to assess the system's performance. However, it was observed that outdoor and indoor environments presented distinct challenges for obstacle detection. Tables 4 and 5 illustrate the system's performance in detecting various distances and providing corresponding alerts in outdoor and indoor scenarios. In outdoor situations, the sensor's ability to identify obstacles provided varying distance measurements due to the wide range of obstacles that may be encountered. While the sensor can accurately detect obstacles placed directly in front of it, indoor environments pose a different scenario. Indoors, the sensor may detect obstacles that are not directly in its line of sight, leading to user confusion regarding the actual obstacle's position. Additionally, variations in distance readings can occur due to environmental factors or Ultrasonic sensor errors when wearing gloves. Nevertheless, the system's detection range remains precise, and the speech recording accurately corresponds to the detected distance.

Table 4. Comparison of different tools of measurements and alerts for Outdoor

Actual obstacle (cm)	**Measured obstacle using measuring tape (cm)**	**Measured obstacle using Glove module (cm)**	**Sensor view**	**Obstacle detected**	**Left/rightof sensor**	**Voice alert by Speaker, Mp3 player, and Vibrating motor (Yes/No)**
26	26	27	Front	Cone	-	Yes
44	44	45	Front	Dustbin	-	Yes
123	123	12	Front	Wall of container	-	No

Table 5. Comparison of different tools of measurements and alerts for Indoor

Actual obstacle (cm)	**Measured obstacle using measuring tape (cm)**	**Measured obstacle using Glove module (cm)**	**Sensor view**	**Obstacle detected**	**Left/rightof sensor**	**Voice alert by Speaker, Mp3 player, and Vibrating motor** (Yes/No)
26	26	28	Front	Luggage	Cupboard	Yes
44	44	47	Front	Laundry bag	People	Yes
123	123	124	Front	Room’s wall	-	No

Table 6 presents a comparison with existing literature, showing that the proposed system shares similarities with previous approaches but offers additional features such as overhead detection and voice alerts through MP3 and speakers. Overall, innovative wearable technology for Visually Impaired People demonstrates promising capabilities in assisting visually impaired users in obstacle detection. However, certain challenges in indoor environments and potential sensor errors suggest opportunities for future improvements.

Table 6. Comparison with existing literature

Ref	Sensor	Controller	Output	System	Detection range (max)	Overhead Detection
[4]	Ultrasonic sensor	Arduino Uno	Vibratingmotor Buzzer Water Sensor	Stick	90cm	No
[16]	Ultrasonic sensor	Arduino Uno	Omnidirectiona l speaker	Robot	Not specified	No
Propo sed	Ultrasonic sensor	Arduino Uno	Microphone Speaker Mp3 playerVibrating Motor	Glove	400 cm (Set 2 cm-100 cm)	Yes

3.2 Probation tests for an actual and measured distance

Three probation tests are being conducted for a few different distances in addition to the three major distances of 26 cm, 44 cm, and 123 cm. These tests were done to determine the performance of the distance evaluated by an Ultrasonic sensor. Additionally, it is assessed by blind people as a user. Illustrations of an experimental setup can be seen in Figure 9.

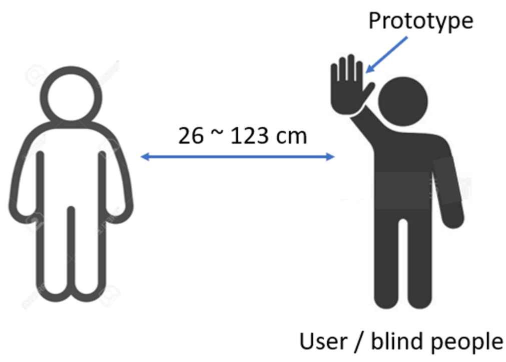


Fig. 9. Probation test experimental setup.

Table 7 presents the results of the probation tests conducted to evaluate the system's performance, showing the percentage error observed. Notably, the percentage error, %, remains within an acceptable range, not exceeding 100%, making these results satisfactory. The actual distance measurements were taken using a measuring tape and the serial monitor in the Arduino IDE software. While the sensor readings might show slight variations from the actual obstacle distances, the deviations are not significantly far off from the real values. Despite the sensor's slight inefficiency, the voice recording function remains accurate, ensuring that the system can still effectively alert users about obstacles. As a result, this issue did not have a substantial impact on the overall system's performance. However, it is important to address this concern in future iterations of the project to further enhance the system's precision. Moreover, variations in distance measurements might arise from environmental factors [17], human error [18], and imprecise materials during the experimental process [19]. Such measurement errors are common and can be challenging to eliminate entirely. Nevertheless, the observed errors are minor and fall within an acceptable range, allowing the results to be deemed credible.

Table 7. Probation tests and percentage error of the proposed system

Distance (cm)	1st trial (cm)	2nd trial (cm)	3rd trial (cm)	Average	% Error
2	3	2	1	2	0.0
20	20	20	20	20	0.0
40	40	41	42	41	2.5
60	60	61	61	60.7	1.2
80	80	81	83	81.3	1.6
100	103	101	102	102	2.0
123	130	124	125	126.3	2.7

Table 8 illustrates the comprehensive working principles of the entire project, providing a clear overview of its functionality and operation. The Ultrasonic sensor used in the Innovative Wearable Technology for Visually Impaired People has an actual distance range of 2 cm to 400 cm. However, for this specific project, the maximum detection range has been set at 100 cm. Extensive evaluations and considerations have led to the determination that a detection range of 100 cm is most suitable for blind individuals while walking. This distance strikes a balance, being neither too far nor too close to effectively identify obstacles in their path. Despite some minor flaws, the system effectively aids users in detecting obstacles during navigation. To further enhance its accuracy and reliability, future developments should focus on addressing these areas of improvement.

Table 8. Working principle of the proposed system

Distance (cm)	Speaker& MP3	Motor	Condition
101-400	No response	No response	The Speaker, MP3 Player, and Motor will not activate because the obstacle is outside the detecting range of 2 cm to 100 cm. At this point, the user can confidently walk because there is no obstacle in front.
81-100	"There are people in front;the distance is 81 cm to 100 cm."	Vibrates	The speaker will operate with the 0005.MP3 recordings folder with normal voice recording speed.
61-80	"There are people in front;the distance is 61 cm to 80 cm."	Vibrates	The speaker will operate with the 0004.MP3 recordings folder with normal voice recording speed.

41-60	"There are people in front;the distance is 41 cm to 60 cm."	Vibrates	The speaker will operate with the 0003.MP3 recordings folder with normal voice recording speed.
21-40	"There arepeople in front; the distance is 21 cm to 40cm."	Vibrates	The speaker will operate with the 0002.MP3 recordings folder with normal voice recording speed.
2-20	"There are people in front; the distance is2 cm to 20 cm."	Vibrates	The speaker will operate with the 0001.MP3 recordingsfolder with a slow-motion voice recording.

4 Conclusions

In conclusion, the wearable device for the blind, consisting of sensor-equipped glove modules worn on the right hand, has been successfully developed. These gloves are designed to be small, lightweight, and easily portable, making them accessible to all users. The device's cost-effectiveness and readily available components contribute to its widespread applicability. Its intuitive design requires minimal instruction, which proves advantageous for blind individuals. During navigation, users wear the glove module on their right hand and follow the biomechanical movements of the carpus for effective obstacle detection. Simulation results were encouraging, accurately identifying various distances that correspond to real hardware outcomes. The system's effectiveness in determining varying obstacle distances demonstrates its unique capacity to assist the visually impaired. The ultrasonic sensor's capability to measure different distances and its integration with the SD card's recording files further enhances the system's functionality and usability. The developed wearable technology presents a promising solution for visually impaired individuals, providing efficient obstacle detection and navigation assistance.

References

1. D. E. Gbenga, A. I. Shani, and A. L. Adekunle, “Smart Walking Stick for Visually Impaired People Using Ultrasonic Sensors and Arduino,” *International Journal of Engineering and Technology*, vol. 9, no. 5, 2017, doi: 10.21817/ijet/2017/v9i5/170905302.
2. H. Son and J. Weiland, “Wearable System to Guide Crosswalk Navigation for People With Visual Impairment,” *Frontiers in Electronics*, vol. 2, 2022, doi: 10.3389/felec.2021.790081.
3. J. M. Rickly, N. Halpern, M. Hansen, and J. Welsman, “Travelling with a guide dog Experiences of peoplwith vision impairment,” *Sustainability (Switzerland)*, vol. 13, no. 5, 2021, doi: 10.3390/su13052840.
4. J. Rothe, S. Ubhade, A. Lute, M. Thenge, M. Charpe, and H. Ambulkar, “Smart Walking Stick for Blind People,” *International Journal of Advanced Research in Science, Communication and Technology*, 2021, doi: 10.48175/ijarsct-1143.
5. A. J. Ramadhan, “Wearable smart system for visually impaired people,” *Sensors (Switzerland)*, vol. 18, no. 3, 2018, doi: 10.3390/s18030843.
6. Y. W. Bai and Y. F. Huang, “Distance tracking for the remote control of an MP3 player,” *IEEE Transactions on Consumer Electronics*, vol. 55, no. 1, 2009, doi: 10.1109/TCE.2009.4814439.

7. U. Hatthasin, N. Setamung, P. Piyawongwisal, and S. Tisom, “A talking distance measuring wheel for the visually impaired,” in *ECTI-CON 2018 - 15th International Conference on Electrical Engineering/Electronics, Computer, Telecommunications and Information Technology*, 2019. doi: 10.1109/ECTICon.2018.8619923.

8. P. G. Pai and R. Srinath, “Implementation of Smart Stick for Obstacle Detection and Navigation,” *International Journal of Latest Research in Engineering and Technology (IJLRET) www.ijlret.com* ||, vol. 02, 2016.

9. M. S. Farooq *et al.*, “IoT Enabled Intelligent Stick for Visually Impaired People for Obstacle Recognition,” *Sensors*, vol. 22, no. 22, 2022, doi: 10.3390/s22228914.

10. R. A. Z. Daou, J. Chehade, G. A. Haydar, A. Hayek, J. Boercsoek, and J. J. S. Olmedo, “Design and Implementation of Smart Shoes for Blind and Visually Impaired People for More Secure Movements,” in *Proceedings of the International Conference on Microelectronics, ICM*, 2020. doi: 10.1109/ICM50269.2020.9331779.

11. P. R. R. Porkodi and P. G. Student, “SMART SHOES FOR BLIND USING INTERNET OF THINGS A REVIEW,” 2021.

12. F. S. Kamaruddin, N. H. Mahmood, M. A. A. Razak, and N. A. Zakaria, “Smart Assistive Shoes with Internet of Things Implementation for Visually Impaired People,” in *Journal of Physics: Conference Series*, 2021. doi: 10.1088/1742-6596/2107/1/012030.

13. C. M. Yang, J. Y. Jung, and J. J. Kim, “Development of obstacle detection shoes for visually impaired people,” *Sensors and Materials*, vol. 32, no. 6, 2020, doi: 10.18494/SAM.2020.2866.

14. M. Dragusanu, A. Villani, D. Prattichizzo, and M. Malvezzi, “Design of a Wearable Haptic Device for Hand Palm Cutaneous Feedback,” *Front Robot AI*, vol. 8, 2021, doi: 10.3389/frobt.2021.706627.

15. A. Chaudhary and Dr. P. Verma, “State of Art on Wearable Device to Assist Visually Impaired Person Navigation in Outdoor Environment,” *SSRN Electronic Journal*, 2019, doi: 10.2139/ssrn.3350316.

16. A. Tsuchiya, K. Mizutani, N. Wakatsuki, and T. Ebihara, “Estimation of Distance to Wall Surface using Omnidirectional Speaker,” in *2019 IEEE 8th Global Conference on Consumer Electronics (GCCE)*, 2019, pp. 1–4. doi: 10.1109/GCCE46687.2019.9015286.

17. D. H. Hagan and J. H. Kroll, “Assessing the accuracy of low-cost optical particle sensors using a physics-based approach,” *Atmos Meas Tech*, vol. 13, no. 11, 2020, doi: 10.5194/amt-13-6343-2020.

18. K. Velmurugan, S. Saravanasankar, P. Venkumar, R. Sudhakarapandian, and G. Di Bona, “Hybrid fuzzy AHP-TOPSIS framework on human error factor analysis: Implications to developing optimal maintenance management system in the SMEs,” *Sustainable Futures*, vol. 4, 2022, doi: 10.1016/j.sftr.2022.100087.

19. H. Y. Teh, A. W. Kempa-Liehr, and K. I. K. Wang, “Sensor data quality: a systematic review,” *Journal of Big Data*, vol. 7, no. 1. 2020. doi: 10.1186/s40537-020-0285-1.