Development of a Low-Cost Obstacle Smart Walking Stick for the Blind

Ayaan Rohila[1], Hitarth Bhargava[1], Arun Rajore[2], Palash Goyal[2]

[1]*High School Student, Atal Tinkering Lab, Happy Days School, Shivpuri, Email: mt24x7@gmail.com*
[1]*High School Student, Atal Tinkering Lab, Happy Days School, Shivpuri, Email: Hitarthbhargava6646@gmail.com*
[2]*Atal Tinkering Lab In charge, Happy Days School, Shivpuri, M.P., India.* Email: *arunrajore@yahoo.com*
[2]*Atal Tinkering Lab In charge, Happy Days School, Shivpuri, M.P., India.* Email: *goyal.palash77@gmail.com*

---***---

Abstract - *Traditionally, visually impaired persons used a stick to see if there were any impediments in their path. This method is inefficient in many ways, and the person who uses it has to deal with a variety of issues. This research aimed to improve mobility for a blind person by developing an obstacle-detecting walking stick with sound play with ultrasonic sensors. Both hardware and software were used in the project. Ultrasonic sensor, buzzers, a vibrator sensor, and a microcontroller make up the hardware, while Arduino Integrated Development Environment (Arduino IDE) was utilised to programme the Arduino uno in the software. The hardware components were housed in a Polyvinyl Chloride (PVC) casing. The ultrasonic obstacle detector was set to identify objects at a distance of 100 cm or less and sound the buzzer to inform the blind person. The vibrator sensor also vibrates the stick to assist the blind. This stick was used to detect barriers in a room with various objects placed in various positions by blindfolded participants. When comparing the produced ultrasonic walking stick to a standard white cane, the results revealed a 90% reduction in collision rate. This demonstrates that the ultrasonic walking stick is safe for a blind person to use at home.*

1.INTRODUCTION

With the use of common tools like the white cane (Kim & Cho, 2013) [1], guiding dogs and their children who are usually deprived of going to school, blind people have been able to move independently, safely, and confidently (Kuyini & Alhassan, 2016) [2]. Blind people swing their white stick around their legs to confirm the presence of an obstruction in their way, whereas a guide dog is trained to help their master avoid any barriers during travel but both have their limitations, The cane can only detect obstacles when it comes into contact with it, and it may not be able to identify whether an obstacle is located at distance away (Faria et al., 2010) [3].As a result, the user will not be alerted to the presence of an obstacle until they have touched it. When barriers are not detected, blind persons can be seriously injured, and their mobility is limited if they don't recognize their circumstances (Chaccour & Badr, 2016) [4]. The conventional white cane does not have a navigation technology to enable a user to navigate such successfully (Pyun, Kim, Wespe, Gassert, & Schneller, 2013) [5]. Research and development groups have focused on assistive technology (AT) like the smart cane. The principal components of most smart canes are ultrasonic sensors, infrared sensors, laser sensors and audio assistance or vibration to increase the mobility of the blind [6-13]. There are different methods that can be used to implement ultrasonic blind walking stick.

Osama Bader AL-Barrm published an article in the International Journal of Latest Trends in Engineering and Technology [14] on a voice-controlled outdoor navigation system for visually impaired people. A stick with ultrasonic sensors, GPS, and an audio output device is used. The stick includes GPS as well as an SD memory card for storing different locations. The user can enter the desired location using voice instructions. This device will also tell you how fast you're going and how far you have to go to get to the distention. The speech system will trigger the alert voice when the ultrasonic sensors detect any obstacle directly. This system is described as a low-cost system that the user can afford. Furthermore, it may provide the user with the most accurate voice instruction available. The system makes use of an ARM CPU, which has more memory space and hence has a faster operating performance. This approach, however, will not work indoors because the GPS system will not receive a signal. Because it can only be operated within 5 metres of radios, the GPS signal's accuracy must be increased. And then, the blind person must be trained on the system in order to efficiently use it.

All of the papers that were evaluated and the study conclusion demonstrate that using ultrasonic sensors to detect obstacles for constructing a smart stick for blind people would be an effective option. The ultrasonic sensors, on the other hand, operate well at a 45-degree angle. Because the ultrasonic sensors have a range of 2cm to 4m, obstructions in front of them can be easily identified.

As a result, the goal of this project was to create a simple and low-cost ultrasonic walking stick that could detect obstacles and pits, allowing a blind person to react quickly to impediments and depressions in their path while also evaluating the intervention's effectiveness.

2 METHODOLOGY

2.1 Materials Used

The components used in the development of the low-cost ultrasonic walking stick for the blind, are listed in Table 1.

Table -1: Materials used in project.

S.No.	Items	Quantity
1	Arduino UNO board	1
2	Arduino IDE Software	1
3	Ultrasonic sensors	1
4	Buzzer	1
5	LED	1
6	Vibrator sensor	1
7	Switch	1
8	9V battery	1
9	PVC pipes	1

2.2 Construction

The project is divided into two phases, the first of which is pre-construction and the second of which is final construction.

2.2.1 Pre-construction

A circuit layout was simulated to test the circuit's effectiveness during the pre-construction stage, and the circuit was then assembled on a breadboard to determine its efficiency and functionality before being placed on the Printed Circuit Board (PCB). The IDE software was installed and programming was completed. This entailed using a USB cord to connect the laptop with the IDE software to the Arduino UNO microcontroller. The code for controlling the entire hardware was written and then uploaded into the memory of the Arduino UNO microcontroller shows in Fig. 1.

2.2.2 Major construction

The circuit's components were transferred to the Printed Circuit Board (PCB) after a successful test of the assembled components on the Breadboard, and correct soldering of all components on the PCB was completed to guarantee that the soldered joints were electrically continuous and mechanically strong. To turn the circuit ON and OFF, the switch was placed at the top of the stick's handle.

(a) (b)

Fig. 1: (a) & (b) The constructed smart walking stick.

2.2.3 Circuit Diagram

The circuit consists of a switch, 9V battery, a voltage regulator, Arduino uno, a Light emitting diode (LED), buzzer, ultrasonic sensor and vibrator sensor. The Battery supplied the necessary voltage to the circuit for the components to work. The circuit diagram, Figure 2 and 3 shows the microcontroller, the buzzers, the LED and the ultrasonic sensor connection. The Flowchart for obstacle detection diagram for the mobility system is shown in Figure 4.

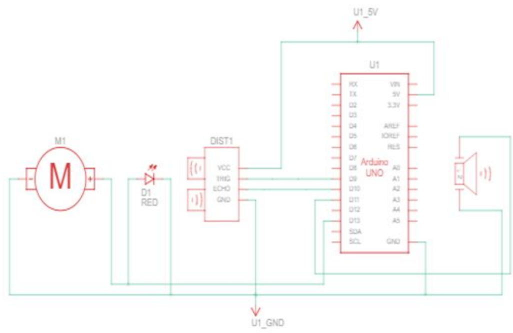

Fig. 2: The overall circuit diagram for the mobility system.

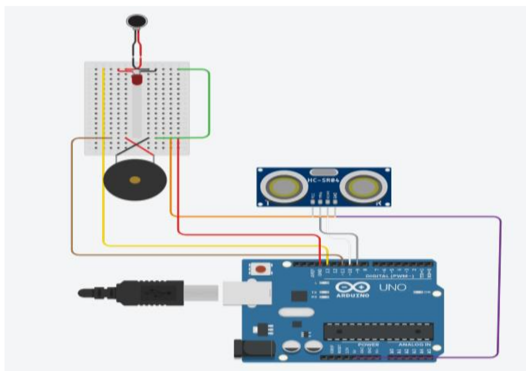

Fig. 3: Circuit diagram for the mobility system.

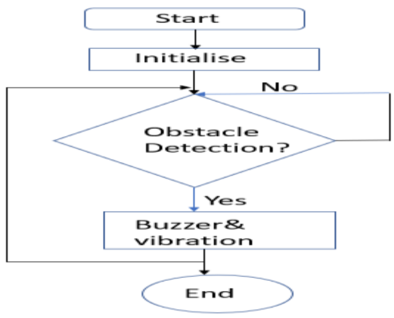

Fig. 4: Flowchart for obstacle detection.

3. RESULTS AND DISCUSSION

The components were verified to be suitable for use, and the application performed as expected. Following the system's development and packing, testing on obstacle detection, collision rate, and responsiveness to various objects were conducted. Before packaging test performed on each component during the pre-construction stage, using testing tools such as a multimeter to see whether the manufacturer's rating was correct or not.

3.1 Obstacle Detection

After packaging, the system was subjected to a series of tests. Using IDE software, the microcontroller was programmed to identify obstacles at various distances ranging from 0 to 60 cm at a 5 cm interval. The system was then exposed to items and the distance at which the system detected the object was recorded and compared to the previously specified distance.

3.2 Collision Rate Test

On an average of 100 trials carried out by blindfolded users, users collided with 47.2 percent obstacles when holding the conventional cane. The ultrasonic walking stick reduced the collision rate to 5.2 percent. This represents a drastic reduction of 88.9 percent when using a smart cane compared to the traditional white cane.

3.4 Response to Various Object Test

When compared to other objects, the smart cane responded more reliably to the concrete wall. This means that the smart stick's capacity to recognize barriers such as a solid wall will be more accurate than plastic, cardboard, or the human body.

4. CONCLUSIONS

Using simple technology, a low-cost obstacle smart walking stick for the blind was designed, and several tests show that the stick is reliable in sensing obstacles. Other findings reveal that when compared to a standard white cane, the smart cane ensures a low collision rate with objects, reducing the collision rate by roughly 88.9%.

The following suggestions can help to improve the development of this technology:

1. By ensuring that the ultrasonic sensor and buzzer's sensitivity is improved, the accuracy of obstacle detection can be improved.

2. Instead of only identifying obstacles, water sensors could be used to detect water on the floor.

3. Two ultrasonic sensors, one for detecting obstacles below the wrist waist and the other for detecting obstacles above the wrist waist, could be mounted in the front.

4. To reduce the size of the smart cane and improve portability, a folding walking stick might be created.

ACKNOWLEDGEMENT

The authors wish to thank Atal Innovation Mission (AIM), NITI Aayog, and all members of the Happy Days School Shivpuri for their invaluable contributions to the success of this design.

REFERENCES

[1] Kim, S. Y., & Cho, K. (2013). Usability and design guidelines of smart canes for users with visual impairments. International Journal of Design.

[2] Kuyini, A. B., & Alhassan, A. R. K. (2016). Caring for Blind Parents: Cost to the Education and Well-Being of Children in Tamale, Ghana. Journal of Social Work in Disability & Rehabilitation, 15(1), 22–41. https://doi.org/10.1080/1536710X.2016.1124252

[3] Faria, J., Lopes, S., Fernandes, H., Martins, P., & Barroso, J. (2010). Electronic white cane for blind people navigation assistance. World Automation Congress (WAC), 2010.

[4] Chaccour, K., & Badr, G. (2016). Computer vision guidance system for indoor navigation of visually impaired people. In 2016 IEEE 8th International Conference on Intelligent Systems, IS 2016 - Proceedings. https://doi.org/10.1109/IS.2016.7737460

[5] Pyun, R., Kim, Y., Wespe, P., Gassert, R., & Schneller, S. (2013). Advanced Augmented White Cane with obstacle height and distance feedback. In IEEE International Conference on Rehabilitation Robotics. https://doi.org/10.1109/ICORR.2013.6650358

[6] Roseli, N. H. M., Aziz, N., & Mutalib, A. A. (2010). The enhancement of assistive courseware for visually impaired learners. In 2010 International Symposium on Information Technology (pp. 1–6). IEEE. https://doi.org/10.1109/ITSIM.2010.5561368

[7] Dang, Q. K., Chee, Y., Pham, D. D., & Suh, Y. S. (2016). A virtual blind cane using a line laser-based vision system and an inertial measurement unit. Sensors (Switzerland). https://doi.org/10.3390/s16010095

[8] Gurkan, K., & Akan, A. (2014). VibroCap: A mobility supporting hat for blind. https://doi.org/10.1109/eleco.2013.6713863

[9] Gurung, S., & Branch, G. (2015). OARC (Obstacle Avoidance and Road Crossing). In 2015 Internet Technologies and Applications, ITA 2015 - Proceedings of the 6th International Conference. https://doi.org/10.1109/ITechA.2015.7317417

[10] Kumar, A., Patra, R., Manjunatha, M., Mukhopadhyay, J., & Majumdar, A. K. (2011). An electronic travel aid for navigation of visually impaired persons. In 2011 3rd International Conference on Communication Systems and Networks, COMSNETS 2011. https://doi.org/10.1109/COMSNETS.2011.5716517

[11] Lakde, C. K., & Prasad, D. P. S. (2015a). Microcontroller based Navigation System for Visually Impaired People. International Journal of Advanced Research in Computer and Communication Engineering, 4(8), 431–435. https://doi.org/10.17148/ijarcce.2015.4893

[12] Selvi, S. S., Kamath, U. R., & Sudhin, M. A. (2008). Andha Asthra - A navigation system for the visually impaired. In IEEE International Conference on Multisensor Fusion and Integration for Intelligent Systems. https://doi.org/10.1109/MFI.2008.4648123
[13] Uddin, M. A., & Suny, A. H. (2015). Shortest path finding and obstacle detection for visually impaired people using smart phone. In 2nd International Conference on Electrical Engineering and Information and Communication Technology, iCEEiCT 2015. https://doi.org/10.1109/ICEEICT.2015.7307355
[14] Osama Bader AL-Barrm International Journal of Latest Trends in Engineering and Technology (IJLTETJ).