Development of Smart Glove System for Blind People

Sahazati Md Rozali[1*], Rozilawati Mohd Noor[1], Aliza Che Amran[1], Saleha Mohd Saleh[1], Iskandar Zulkarnain Hamzah[1]

[1] Faculty of Electrical and Electronic Engineering Technology, Universiti Teknikal Malaysia Melaka, Hang Tuah Jaya, 76100 Durian Tunggal, Melaka, Malaysia.
[*]corresponding author: sahazati@utem.edu.my

Abstract – *In 2010, the Department of Welfare estimated to have about 64,000 registered blind people in Malaysia and believed that the number increased as much as two times higher by 2020. Over the years, the tools typically used by blind people are stick and guide dogs. Blind people use a stick around their feet to detect the presence of an object. However, by using this method, blind people can only detect the object that is closer to them. Some blind people use trained dogs to assist them in their movement. Again, by using this technique, their mobility is also limited since they must depend on the dog. Recently, several electronic travel aids (ETA) have been designed by using several techniques and sensors to ease this group of disabled people. ETA is the common equipment that has been used by blind people to guide their movement from one place to another. Thus, a smart glove system for blind people is proposed in this research as an additional tool to the existing ETA. This system is developed by using Arduino ATMega328, ultrasonic sensors, a vibrating motor, and a buzzer. C language is implemented in microcontroller design. The performance of the designed system is analyzed by using a ping test and mobility test based on the distance range between the wall, which functions as the obstacle to the sensor. The results show that the closer the distance range, the higher the reading of motor vibration and buzzer beeping rate.*

Keywords: *blind, buzzer, distance, motor, ultrasonic sensor*

Article History
Received 27 November 2020
Received in revised form 1 March 2021
Accepted 12 March 2021

I. Introduction

Blindness is the condition of poor visual perception. In 2012, it was revised that 246 million people had low vision and 39 million people were blind. The majority of them are in developing countries within the range of 50 years old. Some of them also have a permanent disability from birth. The World Health Organization stated that "If additional resources are not urgently mobilized and efforts are not made to curb this trend, by 2020 the global burden of blindness can double"[1].

Since this group of people has vision limitations, the usage of suitable equipment or tool is required to ease their movement. For a long time, the white cane is used as a tool for blind people to guide them in their mobility. Another option is the usage of a guide dog to help this group of people.

However, these two techniques have limitations. The white cane can only detect the object or obstacle which is very close to it. The conventional walking stick used by visually impaired people is not so efficient to detect the object in front of an individual. It can only detect the object that is being hit by the walking stick. The user must tap the ground or the object to detect the obstacle. The foremost disadvantage of this type of cane is its failure to detect obstacles outside of its detection volume [2].

Meanwhile, a dog is trained to navigate around the various obstacles and will signal the user if there are obstacles. Guide dogs as previously stated must be professionally trained to guide the blind. However, the use of guide dogs is limited because the dog was unable to understand complex instructions. The guide dog is also compatible only with certain people and religions. Therefore, this method is practically less appropriate.

Thus, the electronic traveling aid (ETA) has been introduced as an alternative to guide their movement. Walking stick with buzzer however can only detect the object within 10cm to 80cm range [3]. Mowat sensor is another type of ETA that had been used as ambulation for individuals with vision impairment and was introduced by Geoffrey C. Mowat in New Zealand in 1976 [4]. The sensor will vibrate when the object detected is within the range of the beam. However, this sensor failed to detect the obstacles on the ground if there are holes or hump and is limited to the distance around the sensor only.

Kay at Canterbury University, Christchurch, New Zealand in [5] created a sonic guide by using application glasses. The improvement of this ETA compared to the previous one was that it is attached with the audio system as an additional tool for this group of people. However, the sound is encoded within a low-frequency tone. Thus, the user needs to estimate the space where the sound is created. Another equipment designed for an individual that used an ultrasonic sensor is search sonic [6]. The tool is hands-free so that it allows the user to handle it freely. Detection of an object is like musical notes and automatically adjusted by the microcomputer which is the controller for this system.

There is also a technology that combines a rod stick with a sensor. The sensor is mounted at the end of the stick's handle and another sensor is attached to the steering wheel and detects the objects around the blind people. This type of rod guide has been widely used and distributed among veterans in a blind rehabilitation centre in western countries [7].

A similar tool with additional sensors and technology on the stick was also developed by [8]. This system comprises a walking stick and Android-based applications (APPs). The walking stick is embedded with Raspberry Pi and a programmable interface controller (PIC) as a control kernel, sensors, a global position system (GPS) module, and alert-providing components.

Another invention by Johann Borenstein [9] is a mobile robot for navigation purposes that is equipped with an ultrasonic sensor and is connected to a computer. In the system, the signal obtained by the sensor is processed in the computer and sent to the user with a stereo imaging technique.

Another robotic system is proposed to assist visually impaired people in unknown indoor and outdoor environments [10]. The robotic system, which is equipped with a visual sensor, laser range finders, speaker, gives visually impaired people information about the environment around them. The laser data is analyzed by using the clustering technique, making it possible to detect obstacles, steps, and stairs. Using the visual sensor, the system can distinguish between objects and humans. The PC analyses the sensor's data and sends information to the visually impaired people by natural language or beep signal.

Most of the ETA for blind people used ultrasonic sensor. There is also a MobiFree system consist of a cane, sunglasses, and echo system. The sunglasses will detect the object above the knee while the echo part is functioned by using the command from the speaker. Besides object detection, the MobiFree allows the user to detect holes. This is the advantage of MobiFree compared to other ETA. There is also a tool called an electronic long stick that is designed for this group of people. However, the main objective of this device is to detect the obstacles above the waist.

This research proposed a smart glove system as an additional tool for the existing ETA. In this study, a prototype of Smart Glove is developed to improve the mobility of blind people. The proposed system uses ultrasonic sensor HC-SR04 technology as a sensor to detect obstacles which will activate the buzzer and vibrator when the user is getting close to it. The distance measured by the ultrasonic sensor will be transmitted to the receiver. The measured data is displayed on the LCD screen. The vibration motor and buzzer are an extra indicator to the user compared to other existing tools which is the advantage of this prototype.

II. Methodology

The project mainly consists of two parts: hardware design and software design. The hardware part involves the usage of Arduino Uno ATMega328 microcontroller, ultrasonic sensor HC-SR04, motor, and buzzer. The software part is developed by using C language. The ultrasonic sensor used sonar to determine the distance of the object or obstacle while the buzzer is installed as an alarm indicator to the user by producing a sound that depends on the distance between the sensor and the object detected.

This type of sensor is chosen because it is user-friendly with a small size. This sensor could detect an object at a minimum distance of 2 cm to 400 cm at an angle of 30 degrees. Its sensitivity can reach up to 3mm. The operation of HC-SR04 starts by receiving a high pulse. Sound waves are used to calculate the time between sending and receiving signals. To detect the presence of an obstacle, an eight-cycle ultrasound at a frequency of 40 kHz is required.

A vibration motor is attached to this designed prototype as an extra indicator that will operate synchronously with the buzzer. The closer the sensor with the object or obstacle, the higher volume and vibration will be produced by the buzzer and motor respectively. When there is an obstacle is detected, the ultrasonic sensor sends feedback to the motor to vibrate and buzzer to produce sound as an alarm indicator. Therefore, the alarm and motor vibrate in different strengths based on the distance from the obstacles. The ultrasonic sensor used for this system and a vibration motor is shown in Fig. 1 and 2 respectively.

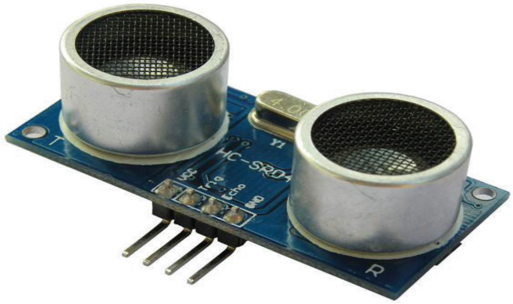

Fig. 1. Ultrasonic SensorHC-SR04

Fig. 2. Vibration Motor

The microcontroller Arduino Uno ATMega328 is programmed by using C language. The circuit of the system is designed by using Proteus PCB Design. UCOOA which is a type of USB to UART converter circuit is used to upload the code to the microcontroller. This method allows the computer to be connected directly via a USB port as a serial communication without using Arduino and only a 5V supply is required in the operation. Fig. 3 shows the schematic diagram of the designed system.

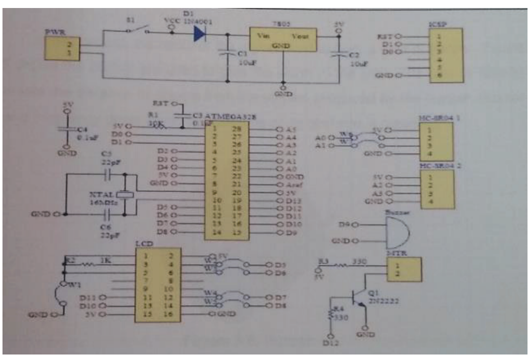

Fig. 3. Schematic diagram of the designed system

Fig. 4 shows the hardware implementation of the mobility system. Ultrasonic sensor HC-SR04 is placed facing forward to detect obstacles. Ultrasonic sensor functions at the best angle of 30 degrees. Two ultrasonic sensors are used. The buzzer and vibration motor are placed approximately at 2 cm from ultrasonic sensors. Each component is arranged such that the design of the system is small, light, and portable.

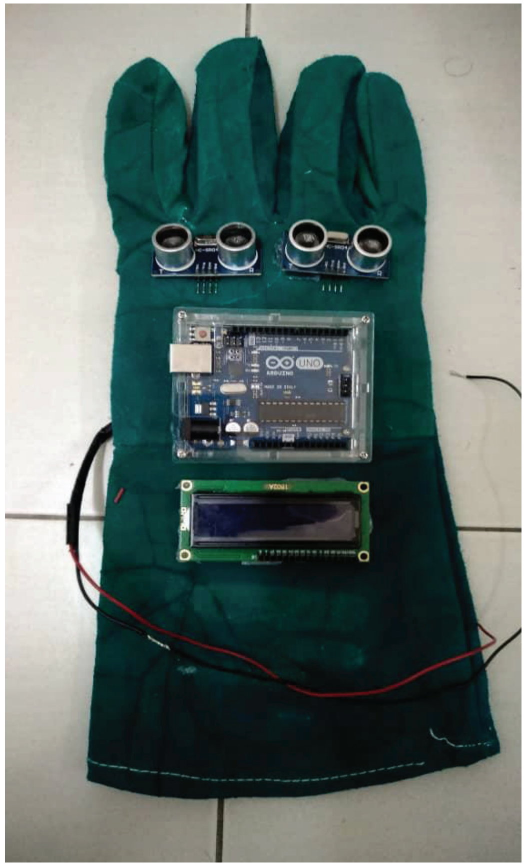

Fig. 4**.** Implementation of mobility system hardware

III. Results and Discussion

The performance of the designed system is analyzed by a ping sensor test. The test is made at a different range of distance between the wall which functions as an obstacle and ultrasonic sensors. The range of distance is chosen between 2cm until 70cm. Table I records the result of the ping sensing test to obstacles at a different range of distance. Table I lists down the value of vibration motor and buzzer beeping per minute at each different range of distance.

Based on the table, the motor vibration per minute is increased when the distance range of the sensor and the obstacle is getting closer. In this study, the distance range below 10cm will give an infinity value of vibration per minute.

TABLE I
PING SENSING TEST TO OBSTACLES

No	Distance range (cm)	Vibration motor (vibrate/min)	Buzzer beeping rate (beep/min)
1	2-10	∞	∞
2	11-25	724	724
3	26-40	523	523
4	41-55	321	321
5	56-70	120	120
6	≥70	0	0

A similar situation happened on the buzzer beeping rate. The beeping sound is getting higher when the distance range between sensor and wall is getting nearer which is below 10cm. This result shows that the ping sensor test to detect the obstacle is successful. The distance of obstacles is directly proportional to the strength of vibration and beep sounds. It can be seen in the graph in Fig. 5.

To prove the persistency of the ultrasonic sensor used in this study, an additional analysis is performed by comparing the distance measured by the ultrasonic sensor with the real distance in the testing operation. The error between these two measurements is recorded in Table II and the data is plotted in Fig. 6 respectively.

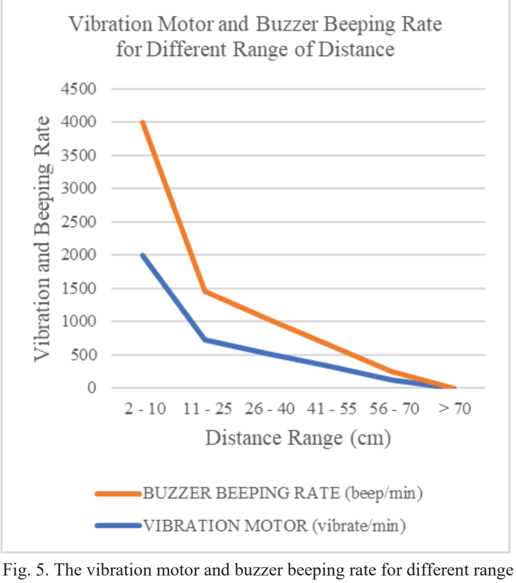

Fig. 5. The vibration motor and buzzer beeping rate for different range of distance

TABLE II
REAL DISTANCE MEASUREMENT AND ULTRASONIC SENSOR MEASUREMENT RESULT

Measurement Number	Real distance measure(cm)	Ultrasonic distance measure (cm)	Error (cm)
1	10	9	1
2	20	19	1
3	30	29	1
4	40	39	1
5	50	48	2
6	60	58	2
7	70	69	1
8	80	79	1
9	90	88	2
10	100	98	2

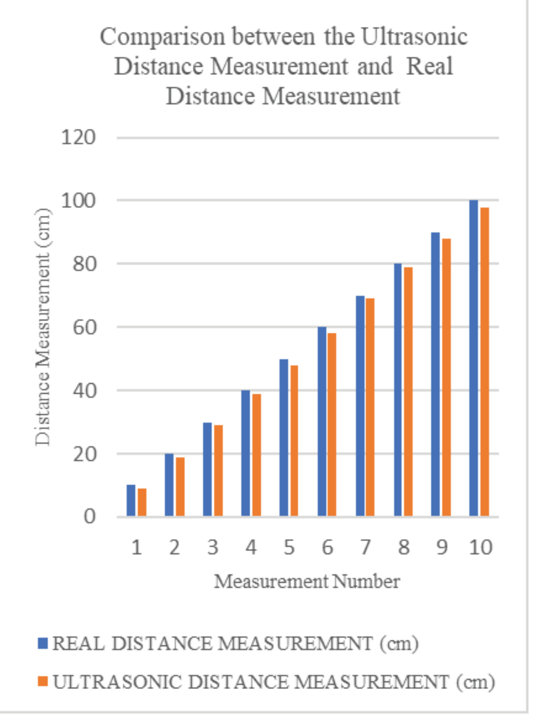

Fig. 6. The distance measurement of the ultrasonic sensor compared to the real distance

Ten readings were taken in this analysis and the observation proves the accuracy of the sensor's measurement since the error between these two recorded data is very small around 1-2cm. This is the reason the ultrasonic sensor is always chosen to be used in most ETA for blind people.

IV. Conclusion

A small, light, and portable smart glove system for blind people is developed by using an ultrasonic sensor. A buzzer and vibration motor are the extra characteristics of this tool compared to the existing ETA for this group of people. These two indicators will operate simultaneously as the blind approach the obstacles in front of them. The designed system has been able to detect the object or obstacles up to 70cm long so that the early warning is informed to blind for their safety.

Acknowledgements

This project is the pre-requisite to the grading of course Bachelor of Electrical Engineering Technology (Automation & Robotics) in the Faculty of Electrical & Electronic Engineering Technology. This work was supported in part by Universiti Teknikal Malaysia Melaka (UTeM).

References

[1] B.S.Sourab, Ranganatha Chakravarthy H.S, Sachith D'Souza. Design and Implementation of Mobility Aid for Blind People. In: *International Conference on Power and Advanced Control Engineering (ICPACE), pp 290-294, Bengaluru India, 2015*

[2] S. K. Bahadir, V. Koncar, and F. Kalaouglu, Wearable Obstacle Fully Integrated to Textile Structures for Visually Impaired People, *Sensors Actuators. A Phys; 179: 297-311, 2012*.

[3] Nimran Kaur, Ayush Sharma, Manisha Gururani, Atul Kumar Srivastava. Electronic Travel Aid System for Blind People, *International Journal of Electrical, Electronics and Data Communication; 5(6): 45-46, 2017*.

[4] Eugene F. Murphy, Earl A.Lewis, Thomas J. Radley, William M. Bernstock, Anthony Staros, Howard Freiberger, Edward Peizer, *Bulletin of Prosthetics Research, Department of Medicine and Surgery Veterans Administration, Washington DC, 1976*

[5] P.L.Emiliani. Development of Electronic Aid for Visually Impaired, *Rehabilitation of Visually Impaired, Italy, 1986*

[6] Daniel Goleman, Sonic Device for Blind May Aid Navigation, *Science Time, New York, p 1, 1994*

[7] Ayat Nada, Samia Mashali, Mahmoud Fakhr, Ahmed Farag Seddik. Effective Fast Response Smart Stick for Blind People, *2nd International Conference on Advances in Bio-Informatics and Environmental Engineering, pp. 1-7, Italy, 2015*.

[8] Nilima Sahoo, Hung-Wei Lin, and Yeong-Hwa Chang. Design and Implementation of a Walking Stick Aid for Visually Challenged People, *Journal of Sensors, 19(1): pp 1-17, 2019*

[9] Ter-Feng Wu, Pu-Sheng Tsai, Nien-Tsu Hu, Jen-Yang Chen. Intelligent Wheeled Mobile Robots for Blind Navigation Application, *Engineering Computations, 34(2): 214-238, 2017*

[10] Genci Capi, Hideki Toda. A New Robotic System to Assist Visually Impaired People, *IEEE ROMAN Conference, 2011.*