SMART SHOE FOR VISION IMPAIRMENT PERSON

BAHARUDDIN MUSTAPHA[a], NUR ASSYIRA ZAINAL ABIDIN[b], NORSHAM HASAN[c]
[a] *Department of Electrical Engineering,*
Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Malaysia
baharuddin@psa.edu.my

[b] *Department of Electrical Engineering*
Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Malaysia
assyira_zainal@yahoo.com

[c] *Centre for Medical Electronic Technology*
Politeknik Sultan Salahuddin Abdul Aziz Shah, 40150 Shah Alam, Malaysia
norshamhasan@yahoo.com

ABSTRACT

People with visual disability have experienced difficulty to travel in an unknown environment. An assistive device is needed to aid them in moving around for a safe journey. The development of a smart shoe is intentionally designed to replace the traditional cane in assisting visually impaired people during walking, especially for an indoor environment. The developed smart shoe consists of two parts which are hardware and software. Hardware components include microcontroller (Arduino Uno), buzzer, vibration, and ultrasonic sensor. The sensor is attached to the shoe for detecting the obstacles which directly connected to the microcontroller for further processing and displaying the output. Buzzer and vibrator are the modalities used to alert the vision impairment person when the obstacle is detected. The strength of the alarm and vibration depends on obstacles detection at different distances. It will increased automatically when the detected obstacles closer to the user. Preliminary results show that the percentage of obstacles detection is reliable and has achieved 96% of accuracy. The accuracy of obstacles detection in multiple angles can be improved further by adding more sensors at suitable locations of the shoe. Hence, the proposed smart shoe prototype is comfortable to wear and very convenient to use as a moving aids when traveling for both indoor and outdoor environment.

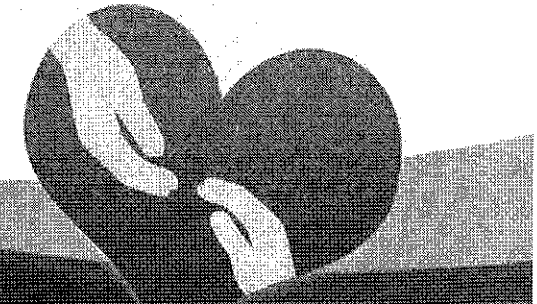
Keywords: assistive device; obstacle detection; smart shoe; travel

Instruction
*Scope of field for presentation (Please tick **ONE** only):*

- [ ] *Early Intervention & Care*
- [ ] *Learning & Innovation*
- [ ] *Transition Program*
- [ ] *Inclusive Education*
- [ ] *Sexuality Education*
- [ ] *Projection & Learning Approach*
- [ ] *Individual Education Plans*
- [ ] *Sahsiah, Pure Value and Fardhu Ain*
- [ ] *ICT & Assistive Technology in Special Education*
- [ ] *Early Education & Higher Education*
- [ ] *Therapeutic Activities*
- [ ] *Disabilities & Literacy Disability*
- [ ] *Emotional Quotient (EQ) and Spiritual Quotient (SQ)*
- [x] *Technical and Vocational Education Training (TVET)*
- [ ] *Empowering Families & Participation*

SPECIAL EDUCATION INTERNATIONAL CONFERENCE (SEIC) 2019

SPECIAL EDUCATION : ACCESS AND QUALITY



ORGANIZED BY

MINISTRY OF EDUCATION MALAYSIA

DYSLEXIA PARENTS

IN COLLABORATION WITH

PETRO TEKNIK (M) SDN. BHD.

25 TO 27 SEPTEMBER 2019
PUTRAJAYA MARRIOTT HOTEL

WEBSITE : www.moe.gov.my/seic2019kpm
REGISTRATION FORM : http://survey.moe.gov.my/panel/index.php/911288

THEMES

Special Education: Access and Quality

SUB THEMES

- Early Intervention and Care
- Learning and Innovation
- Transition Program
- Inclusive Education
- Sexuality Education
- Projection and Learning Approach
- Individual Education Plans
- ICT and Assistive Technology
- Empowering Families and Participation
- Technical and Vocational Education Training (TVET)
- Therapeutic Activities
- Deaf Blind and Multiple Disability
- Disabilities and Literacy Development
- Early Education
- Higher Education
- Coorporate Social Responsibilities (CSR)
- Emotional and Spiritual Intelligences
- Fardhu Ain's for Special Education

REGISTRATION FEE

Presenter / Participant / Poster Presentation / Exhibition

Early Bird Registration
Date : 1 April 2019 to 31 June 2019

- International : USD200.00
- Malaysian : RM200.00
- Malaysian Student (First Degree) : RM150.00

Normal Registration
Date : 1 July 2019 to 31 July 2019

- International : USD250.00
- Malaysian : RM250.00
- Malaysian Student (First Degree) : RM200.00

Exhibition (2 Exhibitor 1 Booth)

- International : USD400.00
- Malaysian : RM1,500.00

IMPORTANT DEADLINE

Abstract Submission	: 20 June 2019
Abstract Acceptance Notification	: 30 June 2019
Full Paper Submission	: 31 July 2019

Registration & Payment for Presenter/Participant/ Poster Presentation/Exhibition

Early Bird	: 31 June 2019
Normal	: 31 July 2019
Registration & Final Payment	: 31 July 2019

REGISTRATION PAYMENT

Pay via bank transfer to :

Dyslexia Parent Support Organization of Malaysia / Pertubuhan Sokongan Ibu Bapa Dyslexia Malaysia (PSIDM)

Maybank Berhad (MBB)
5644 2751 3413
Please quote reference : SEIC 2019

IMPORTANT :
Send a proof of payment (slip) to :
seic2019kpm@gmail.com and account@psidm.org.my
Non-Refundable

PUBLICATION OF PAPERS / ARTICLES

Selected articles or papers will be published in one of the following journals:

1. Asian Journal Of Instruction, Turkey
2. International Journal Of Innovation And Industrial Revolution
3. International Journal Of Language Education And Applied Linguistics, Malaysia

SECRETARIAT OF THE CONFERENCE

Futher information please call :

General

- +603-8884 6693
- +603-8883 0617
- +603-8883 0715
- +6017-483 8058
- +6019-223 5481

Smart Shoe for Vision Impairment Person

Baharuddin Mustapha[1], Nur Assyira Zainal Abidin[1], Norsham Hasan[2]

[1]*Department of Electrical Engineering, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor*
[2]*Centre for Medical Electronic Technology, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor*

Abstract: People with visual disability have experienced difficulty to travel in an unknown environment. An assistive device is needed to aid them in moving around for a safe journey. The development of a smart shoe is intentionally designed to replace the traditional cane in assisting visually impaired people during walking, especially for an indoor environment. The developed smart shoe consists of two parts which are hardware and software. Hardware components include microcontroller (Arduino Uno), buzzer, vibration, and ultrasonic sensor. The sensor is attached to the shoe for detecting the obstacles which directly connected to the microcontroller for further processing and displaying the output. Buzzer and vibrator are the modalities used to alert the vision impairment person when the obstacle is detected. The strength of the alarm and vibration depends on obstacles detection at different distances. It will increased automatically when the detected obstacles closer to the user. Preliminary results show that the percentage of obstacles detection is reliable and has achieved 96% of accuracy. The accuracy of obstacles detection in multiple angles can be improved further by adding more sensors at suitable locations of the shoe. Hence, the proposed smart shoe prototype is comfortable to wear and very convenient to use as a moving aids when traveling for both indoor and outdoor environment.

Keywords: assistive device; obstacle detection; smart shoe; travel

Introduction

Visual impairment is functional loss of vision or more known as blindness that can be caused by accidents, illness, and infection or natural disabilities. It can happen to anyone regardless of gender and ages. Visual impairment can be classified into three levels that are mild, moderate and severe. A person in level mild can read relatively larger characters and no difficulty in identifying shape, colour and brightness contrasts. For moderate level can tell shapes and colours of objects and can distinguish between brightness and darkness. Furthermore, only read characters with larger size and broader strokes. A severe level cannot see anything which is completely blind.

Technologies today have been developed a wearable device for the blind to help them for reading, navigation, security, and many more. The smart walking stick has been introduced to assist visually impaired people in navigation. The use of smart walking stick could alert the vision loss person from existing obstacles in front that may be encountered and hollow detection circuitry by voice and vibration to prevent them from an accident. Perhaps, with the advancement of technology, the device equipped with wireless tools such as Bluetooth earphone to acknowledge blindness of detected obstacles in a noisy environment. The development of a smart shoe may replace the traditional cane for some circumstances and condition to help blind people for moving around. On the other hand, it will tell the users in the form of buzzers or vibrates if obstacles are detected. It depends on the distance and position of the obstacles that reflect them from colliding or fall.

Mobility, orientation and obstacle recognition are key to personal independence for the vision impairment person. Majority of the visually impaired people still using a conventional canes, sensor canes and guide dogs to aid them in navigation especially for an outdoor environment but they have limitations. Recently, new navigation tools have been developed to increase the quality of life of vision impairment person. In some circumstances, people with vision loss disability using the other senses to walk around with the help of advanced navigation devices.

Scientific research shows that hearing and touch can send visual information to the blind. Some vision impairment person relies on hearing senses when crossing the road. The proposed smart shoes may help people with vision limitation to navigate alone without help from other people. The smart shoe equipped with an ultrasonic sensor for obstacle detection and alarm unit to alert the user. The alarm unit consists of buzzer and vibrator. Depending on the obstacles detect, the more closely the faster sound and vibrate of buzzer and vibration. It is easy for the people with a vision disability to rectify the distance between them and obstacle. The ultrasonic sensor had been chosen in this project due to the high accuracy of detection and low-cost (Bousbia-Salah, M. *et. al*, 2011).

The paper is organized into 5 sections. Start with introducing section, then in the next section highlights some contributions from earlier researchers in this field. The methodology section in part III has discussed the development of the device where some results have been displayed in the next section. Finally, section V summaries the achievement of the proposed prototype and highlights further suggestions for future improvement for the system.

Background of the Study

The high demand from the people with eye disability and advance of sensor technology has opened up the opportunity for engineers and scientists to develop sophisticated devices, especially in supporting the vision impairment person for safe navigation. The present of hi-tech assistive devices has helped to improve the quality of life of the blindness by assisting them to live independently in their daily life.

Devices are as diverse as the technology used and the location on the body. The common areas of the body where these wearable assistive devices are promptly attached such as fingers, hands, wrist, abdomen, chest, feet, tongue and ears as illustrated in Figure 1. These part of the body have been acknowledged for sending visual information to the blind. Normally, these wearable devices using feedback modalities such as buzzer, vibrator and audio messages for alerting and guiding purposes. The fixation of these devices on the body is achieved by head-mounted devices, wristbands, vests, belts, shoes and etc.

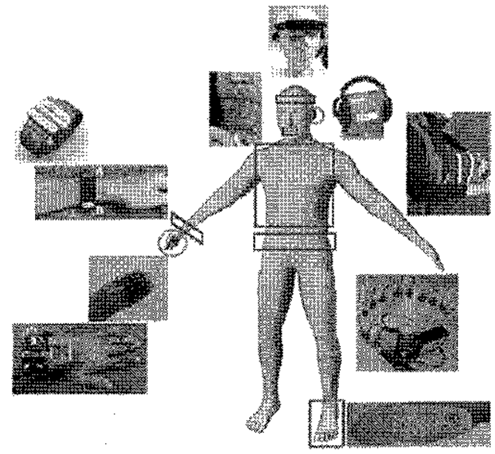


Figure 1 Overview of wearable assistive devices for the blind (Velasquez, R., 2010)

Rehabilitation shoe has been developed for vision loss person to help safe navigation and mobility (Abu-Faraj, Z.O., 2012). The developed shoe composed of 3 pieces of ultrasonic sensors which are being placed on the medial, central, and lateral aspects of the toe cap. The orientation of these ultrasonic sensors has been empirically adjusted to maximize the scope of the sensor beam coverage, allowing it to detect ground-level obstacles of different heights as well as pits and holes, while concurrently minimizing crosstalk among the transducers. Figure 2 shows a prototype of the rehabilitative shoe which has been developed.

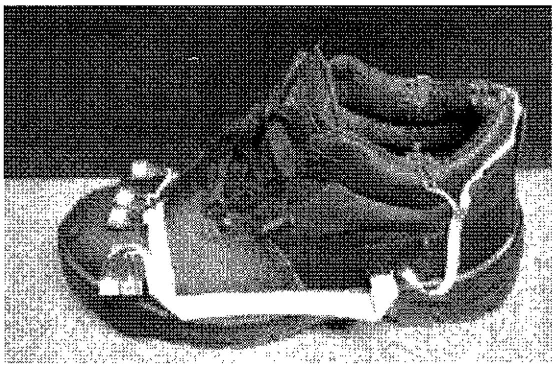


Figure 2 The prototype of the rehabilitative shoe (Abu-Faraj, Z.O., 2012)

An array of ultrasonic sensors are attached to the sport shoe to detect the obstacles while walking has been developed as shown in Figure 3 (Caleb, K., 2013). The idea behind this prototype is that any obstacle will be detected and a physical notice will be given to the wearer in real-time. Vibrating boxes are used as physical feedback to the user when obstacles

baharuddin@psa.edu.my

are detected. Microcontroller polls the ultrasonic sensors and provides feedback through the boxes.

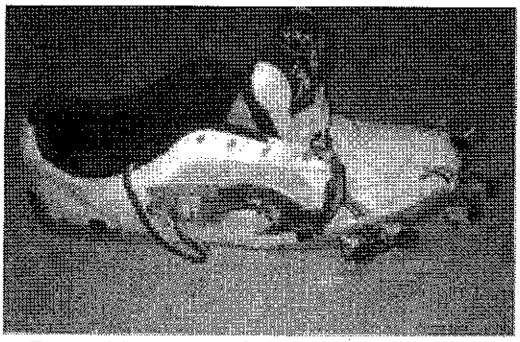


Figure 3 Prototype of ultrasonic shoe sensors (Caleb, K., 2013)

The development of a shoe-integrated tactile is essential tools for collecting data on human-machine interaction (Velazquez, R. *et. al*, 2009). This device allows users to obtain information through touch sensing by applying vibration tactile to the foot. Each vibrator is independently controlled with a specific vibrating frequency command for evaluating touch sensing comprehension level of the visually impaired people. One of the advantages of this mechatronic shoe is that it can be inserted into the bag as an invisible and non-detectable aid. Results show that both healthy-sighted and blind subjects understand easily vibrations encoding simple information such as directional instructions (for example: go forward, backward, turn left, turn right and stop). Figure 4 illustrates the prototype of the shoe-integrated tactile.

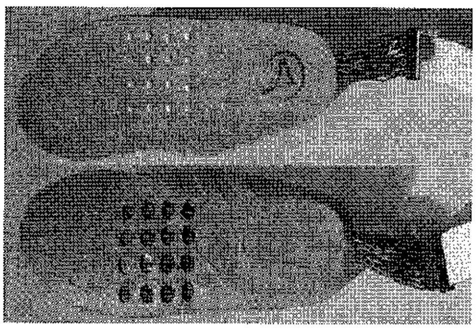


Figure 4 Illustration of the shoe-integrated tactile (Velazquez, R. et. al, 2009)

The development of a haptic shoe named Le Chal (Sharma, A., 2010) as shown in Figure 5 is another effort to assist the visually impaired people for moving around. This device consists of a proximity sensor, vibrators, and microcontroller (LilyPad Arduino) attached in the heel of the shoe and connected to GPS-Enabled Smartphone through Bluetooth. The LilyPad Arduino communicates with the phone through Bluetooth for access to the geographical location. The user acknowledges the route direction through vibration. The vibrator and positions are different and depend on the directions GPS to coordinate and compass, which may activate the system to provide feedback to the wearer depending on the turn he/she needs to take.

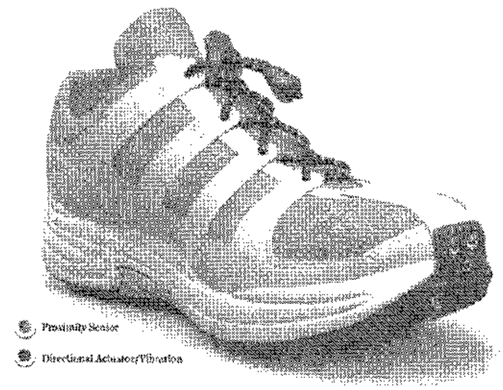


Figure 5 Haptic shoe for visually impaired people (Sharma, A., 2010)

Presently, most of the modern navigation aid use vibrator as feedback modality to replace the use of voice-based modality in a noisy environment. Hence, the uses of multiple sensors for the obstacle detection have helped the researchers to increase the overall performance of obstacle detection for both indoor and outdoor environment (Mustapha, B. et. al, 2012). Microcontroller has play an important role to ensure the detection accuracy of the developed navigation devices (Mustapha, B. et. al, 2014). The multiple warning signals have made the devices more practicable for the blindness to avoid any obstacles in front of them along the pathway.

Nowadays, many researchers use a vibrator as an alerting tool in developing a navigation aid for visually impaired due to sensory touch sensitivity at the human skin is very high. Naturally, human skin is divided by 2 parts which are epidermis (outer layer) and dermis (inner layer). The inner layer has 3 kinds of nerves of the essential biological sensors of touch (e.g., thermoreceptors; responsible for thermal sensing, nociceptors; responsible for pain-sensing and mechanoreceptors; sensitive to mechanical stimulus and skin deformation. Scientists have found four types of mechanoreceptors nerves that are responsible for sensing and transmission of physical deformations by external forces to the nervous system. Figure 6 illustrates the place of the mechanoreceptors nerves which are located inside the dermis layer of the skin. The nerves are called Pacini corpuscles, Ruffini endings, Merkel cells and Meissner corpuscles. Each type of nerves has its own function. Meissner and Pacini corpuscles respond to touch and vibration, respectively, while Ruffini endings respond to the lateral extension of the skin and articular movement and Merkel cells perceive pressure (Kandell, E.R. *et. al*, 2012).

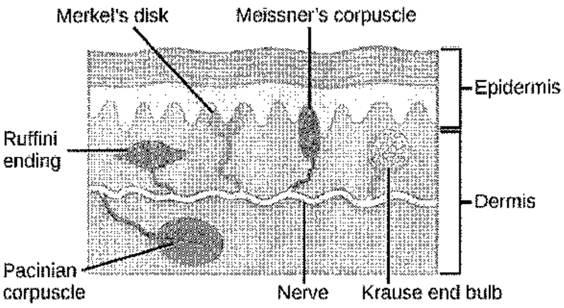


Figure 6 The area of mechanoreceptors nerves at dermis layer (Kandell, E.R. *et. al*, 2012)

The ability of the cutaneous mechanoreceptors to absorb stimuli depends on its position at the foot sole as shown in Figure 7 (Vernon B. B. *et. al*, 1981).

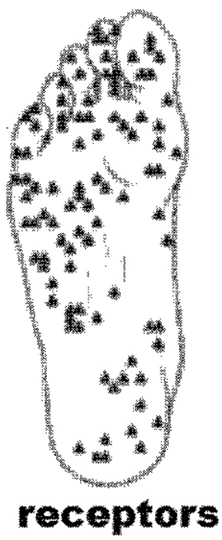


Figure 7 Distribution of cutaneous mechanoreceptors in the foot sole

The stimuli vary throughout the foot sole and it depends on quickly indent and sustain in contact with the mechanoreceptor. The responses could be classified by two which are Fast Adapting (FA) and Slowly Adapting (SA). The area of the FA and SA are illustrated in Figure 8.

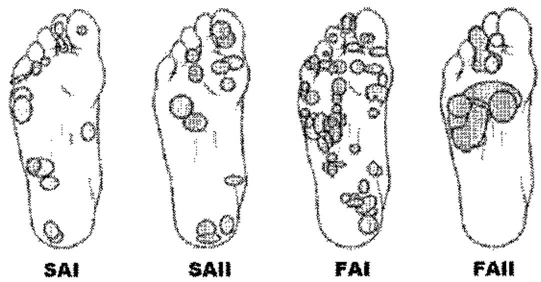


Figure 8 Stimuli responses area of SA and FA at the foot sole

Methodology

This project involve both hardware and software design. The hardware part particularly consists of ultrasonic sensor connected to microcontroller (Arduino Uno) board and the feedback modalities are vibrator and buzzer. Buzzer and vibrator are the alerting modalities used in this proposed prototype. The prototype is developed to help the vision impairment person to navigate independently. Figure 9 shows the block diagram of the proposed device.

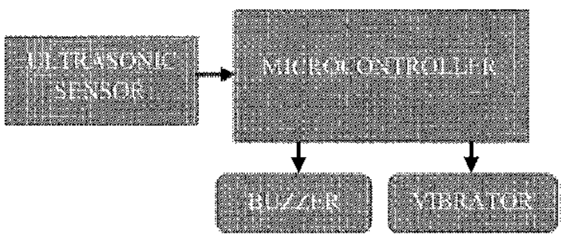


Figure 9 Block diagram of the proposed system

Microcontroller reacts like a heart in this prototype as a liaison tool between the sensor and alerting modality. All the data processing and communication between them are controlled by the microcontroller. An embedded system is a very advanced system that required minimal memory and program length, no operating system and less software complexity. The Arduino Uno is a microcontroller board based on the ATMEGA328. The Arduino Uno is a programmable microcontroller which needs to be programmed in order to drive the designed function. It has 14 digital input/output pins of which can be used as PWM outputs, 6 analog input, a 16MHz crystal oscillator, a USB connection, a power jack, ICSP header, and a reset button. It comprises everything needed to support the microcontroller. Once the settings were done, the microcontroller will read the setting and produced the output based on the initial programming by the user.

Three factors are considered to choose a suitable sensor in the development of the prototype smart shoe. It is environmental factors, economic factors and the characteristic sensor itself. Environmental factors include temperature range, corrosion, size, ruggedness, over range protection and power consumption. This is an important factor to make sure the sensor that attached to the shoe is functioning effectively. The economic factors are the costing and lifetime of the sensor. The longer lifespan is the best quality of sensors. The characteristics of the sensor such as sensitivity, range, stability, linearity and response time are important factors to be considered in choosing a suitable sensor. The ultrasonic sensor has been used in this project because compatible with microcontroller and has an ability to detect any type of obstacles (e.g., metal, wooden, concrete, plastic, glass, etc.) and it is not affected by poor lighting condition (Mohammad, T., 2009). In addition, it can be used in obstacle detection because of its high resolution, low cost, and faster response.

Results and Discussion

The prototype of a smart shoe has been developed as shown in Figure 10. It has been tested to evaluate the general functionality of hardware component coupled with software programming.

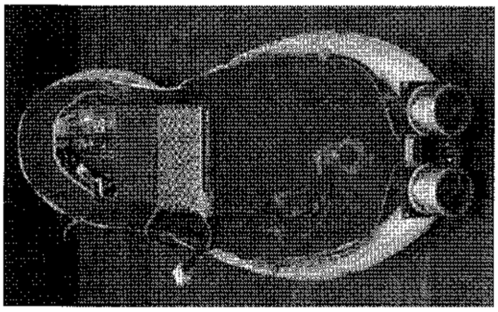


Figure 10 The prototype of a smart shoe

Preliminary test is carried out for an indoor environment to assess its reliability and locality of the components attached to the shoe. The initial test has been conducted to determine the sensibility of the sensors toward the detection of the obstacles in different distances. Table 1 depicts the preliminary results of the sensor detection toward obstacles in various distances.

Table 1
The obstacle detection performance of the sensor at different distances

Actual distance (cm)	Measured distance (cm)	Percentage of error (%)
30	30.20	0.67
50	50.00	0.00
70	69.80	0.29
90	90.10	0.11
110	110.04	0.04
130	130.20	0.14
150	150.28	0.19

The average detection error for the various distances is too small and negligible. The average accuracy of the detection of the obstacle distance is above 96%, which can be considered as a good sign of the system reliability. Various types of obstacle materials have been tested to determine the detection capability of the sensor. Table 2 shows the results for various types of obstacles at a zero degree of angle and 100 cm away from the sensor.

Table 2
Sensor detection for the different types of obstacle materials

Types of material	Measured at 100 (cm)	Percentage of error (%)
Plastic	100.19	0.19
Mirror	100.79	0.79
Wood	99.48	0.52
White paper (A4 size)	99.72	0.28
Aluminium	100.11	0.11

The experiment is extended to the other obstacle materials which are placed at 50 cm, 100 cm, and 150 cm away from the sensor and the recorded result is shown in Table 3.

Table 3
Sensor measurement for various types of obstacles materials at different distances

Types of material	Measured at 50 (cm)	Measured at 100 (cm)	Measured at 150 (cm)
Wall	50.00	100.00	149.60
Human body	49.90	99.80	149.70
Rubber	50.00	100.00	149.90
Metal	50.00	100.00	150.00
Wood	50.00	100.00	149.80

The measurement results show that the sensor has highly sensibility detection towards any type of obstacle materials. The empirical results show that the inaccuracies are in an acceptable range since the differences between the actual value and the measured value are less than 1%. The experimental results show that the sensors are able to detect the obstacles or objects within their usable range with no false detection.Sensors cannot give false detection because it affects the results of the warning system. In order to improve the sensing accuracy of the sensor, a thermistor is connected to the sensor as shown in Figure 11. By adding the thermistor to the circuit, it can control the ambient temperature and gives greater sensing accuracy.

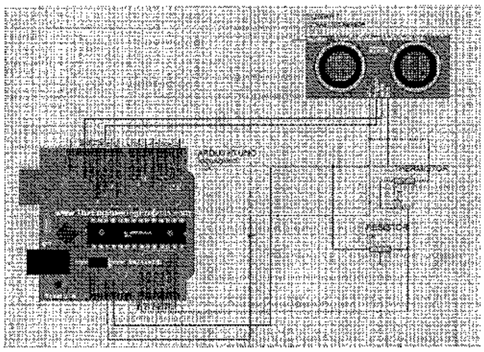


Figure 11 The connection of thermistor in the circuit

The experiment is conducted for the obstacles placed at various distances from the sensor and measurement results obtained is shown in Table 4.

Table 4
Sensing performance with added thermistor

Actual distance (cm)	No added thermistor (cm)	Added thermistor (cm)
30	30.04	30.00
40	40.20	40.00
50	50.28	50.00
70	69.80	70.02
90	90.10	89.98
110	110.10	110.08
130	130.20	130.10
150	150.30	150.15

Conclusion and Further Recommendation

A smart shoe to assist the vision impairment person in in navigation is developed. The empirical results obtained show that this system has average accuracy of above 96%. Experimental work clearly reveals that a high accuracy measurement of obstacle detection is achievable using the selected sensors. The sensors also demonstrated good detection for various types of obstacle materials, colors, sizes and shapes in all environments. This system is quite flexible and allows adjustment according to the user need due to the microcontroller capabilities. Further improvements on the system are required to consider the personal gait analysis and location of the sensor on the shoes.

References

Bousbia-Salah, M., Maamar, B. & Larbi, A. (2011). Navigation Aid for Blind People. *Intelligent Robot System*, 64(3), 387-400.

Velasquez, R. (2010). Wearable Assistive Devices for the Blind. In: Wearable and Autonomous Biomedical Devices and Systems for Smart Environment. vol. 75. Springer Berlin Heidelberg. 331-349.

Abu-Faraj, Z.O., 2012. Design and Development of a Prototype Rehabilitative Shoes and Spectacles for the Blind. Proceedings of *the 5th International Conference on Bio Medical Engineering and Informatics*. Chongqing, China, 16-18 October, 795-799.

Caleb, K., (2013). Ultrasonic shoe sensors help the visually impaired. Electronics-blogs, EDN Network.

Velazquez, R., Bazan, O. and Magana, M., 2009. A Shoe-Integrated Tactile Display for Directional Navigation. Proceedings of *2009 IEEE/RSJ International Conference on Intelligent Robots and Systems*. St. Louis, USA, 11-15 October, 1235-1240.

Mustapha, B., Zayegh, A. and Begg, R. K., 2012. Multiple Sensors Based Obstacle Detection System. Proceedings of *4th International Conference on Intelligent and Advanced Systems 2012* (ICIAS2012). Kuala Lumpur, Malaysia, 12-14 June, 562-566.

Mustapha, B., Zayegh, A. and Begg, R. K., 2014. Microcontroller Based Wireless Obstacle Detection System for the Elderly. Proceedings of *4th International Conference on Artificial Intelligence with Applications in Engineering and Technology 2014*. Kota Kinabalu, Malaysia, 3-5 December, 325-329.

Mohammad, T., (2009). Using Ultrasonic and Infrared Sensors for Distance Measurement. *World Academy of Science, Engineering and Technology*, 3(3), 267-272.

Kandel, E. R., Schwartz, H. J., Jessell, M. T., Siegelbaum, A. S. & Hudspeth, A. J. (2012). *Principles of Neural Science*. New York, USA: McGraw-Hill Education / Medical.

Vernon, B. B., John, M. B. & Vernon, B. M. (1981). *Handbook of Physiology. Section 1: The Nervous System*. Bethesda, USA: American Physiological Society

Maybank

Open 3rd Party Transfer

Status:	Successful
Reference number:	**6796025746**
Transaction date:	**31 Aug 2019 08:22:41**
Amount:	**RM250.00**
From Account:	**153010032375**
To Open 3rd Party Account :	**564427513413**
Account Holder Name :	**PERTUBUHAN SOKONGAN**
TransactionType :	**Open 3rd Party Transfer**
Recipient Reference :	**SEIC 2019**
Other Transfer Details :	

Note: **This receipt is computer generated and no signature is required.**

Maybank2u