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Smart Cane for Visually Impaired with Obstacle, Water Detection and GPS

N.M.A.Nazri[1], S.S.M.Fauzi[1,*], R.A.J.M.Gining[1], T.R.Razak[1], M.N.F.Jamaluddin[1]

[1] *Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Perlis Branch, 02600 Arau, Perlis, Malaysia*

E-mail address: [1,]shukorsanim@uitm.edu.my*

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Abstract: Visual impairment can be termed as a disability that distresses the structure and functions of the visual system. Many people considered blindness as an inability to see at all or at best to perceive light from the darkness. In the context of visual impairment, most people with visual impairment have difficulty to find their way autonomously in an unfamiliar area. Visually impaired people usually use the standard white cane or walking cane to assist them in walking. However, it is not adequate to ensure their safety when navigating in an unfamiliar area. In addition, the current development of the smart cane also has some deficiencies. Therefore, in this paper, we designed a smart cane by integrating it with an ultrasonic sensor to detect obstacles, water sensor for detecting the presence of water puddle, and GPS Module to monitor the blind's location via Blynk. A total of ten respondents with age above twenty years old involved in the functionality test to identify the effectiveness of the proposed system. From the findings, it is learned that the proposed system can increase the protection and safety towards the people while navigating an outdoor or unfamiliar area.

Keywords: Visually impaired, Smart cane, Internet of Things, IoT, GPS.

1. Introduction

People with visual impairments are the people who find it hard to recognize the smallest element with healthy eyes. Globally, 32.4 million people were blind in 2010, and that 191 million people had moderate and suffered from vision impairment [1].

The issues with visual impairment lie in the difficulties in self-navigation in unfamiliar outdoor environments. Use of the traditional cane, guide dogs and mobility training are included in expertise and supports considered by professional working in the field of orientation and mobility to help visionless people [2]. Typically, users tap the cane from left to right and as far ahead as the cane's length. The tapping technique help users to recognize the ground surface in the user's environment [3]. However, the problem with the standard white cane is that it has a limited detection range of obstacles at only a distance equals to the cane's length. Thus, this restricts the users' walking speed and leads the users to assess approaching obstacles outside of the range unconfidently.

Additionally, outdoors could also be a dangerous place for individuals with visual impairment. This is because visually impaired people tend to expose to water puddle or wet walkway. Water puddle may cause visually impaired people to slip and fall. Further, when they slipped and fell, they can get head or below knee-level injuries. It could be worse if there are other objects such as a rock in the water puddle that obstructs their way.

This study provides another piece of work and future research direction by providing an alternative solution in the smart cane body of knowledge and development. The proposed smart cane integrates three different devices which are obstacle detection, water detection and GPS module to monitor the visually impaired location. Furthermore, this study contributes to improving the protection and safety of its user while navigating an outdoor and unfamiliar area.

This paper is organized as follows; section two describes the literature review. System design and development is explained in section three. Results presented in section four, and the paper is concluded in section five.

E-mail:author's email

2. LITERATURE REVIEW

A. Visually Impaired

Visual impairment can be described as an impairment that affects the structure and functions of the visual system. The individuals with vision impairment may also experience disability if they do not have adequate access to support and services, and face barriers such as discrimination or isolated buildings or transport [4]. Besides that, many people regard blindness as an inability to see at all or at best to perceive light from the darkness. World Health Organization (WHO) reported that the number of people with visual impairment is 285 million - 39 million are blind, and 246 million have low vision. There are some different levels of visual impairment that affect a person's daily life in different ways. For instance, people with a severe visual impairment may not be able to drive legally and they may not be able to distinguish the difference between light and dark.

Typically, people with visual impairment are always exposed to an external environment. On the other hand, some places are quite dangerous and challenging for those who are visually impaired as those places will increase the chance of an accident. More than 700,000 people in the United Kingdom (UK) attend the hospital's accident and emergency department each year regarded falls and many more minor injury units [5]. In particular, the number of fall-related accident in the UK in 1999, requiring hospital treatment is 2.35 million in total, and 8.04% of them are individuals with visual impairment [5]. Based on the statistics, it is suggested that visual impairment people need some aid to interact with their environment with higher safety because this situation burdened visually impaired people with problems and challenges in navigating themselves in outdoor environments.

In the context of visually impaired, the common types of mobility aids were canes and guide dogs [6]. The guide dog is a "mobility aid" that can enable visually impaired to travel safely. Guide dogs can guide people around obstacles, through crowds and stop at curbs or stairs. Guide dogs assisted visually impaired in navigating them to walk. However, navigating was alone is not enough to give a high guarantee to protect visually impaired from the obstacles that they faced. Approximately, the guide dogs cost $10,000 for training and to maintain them would cost about $20 per month [6]. The guide dog was not suitable as a mobility aid for all visually impaired. The reason why it was not convenient to use guide dog as mobility aid was because of poor social behavior such as scavenging [7].

On top of that, dogs were not allowed to enter public places such as hotels, public transport and many more [8]. Moreover, guide dogs need to be trained so that the speed at which the guide dog travels must be suitable to the user. Typical walking speed is 5 to 6 kilometres per hour [7]. In conjunction, it is clear that guide dogs were not appropriate to be used as mobility aid because they did not assist the visually impaired enough in order to avoid them from obstacles.

The cane or stick has existed as travelling supports for the blinds and visually impaired yet it was not just a device that can be used to seize self-reliance. However, it was also a sign of the sightless people in society [9]. They used such tools to alert them the obstacles in their way. There are several types of cane which include a long cane, symbol cane, and guide cane. Long cane merely was familiar as the traditional 'white cane' designed for people who have no functional vision and required a contact cane for wayfinding and obstacle location [10].

Moreover, long cane also checked the path 1.5 to 2 steps ahead of the visually impaired, so they had the warning about any obstacles, hazards or surface changes [10]. Symbol cane is another version of a long cane with the difference if it is shorter than a long cane. Symbol cane is not used for checking the area in front of the visually impaired person but for letting people around them knew that they are blind or have partially sighted [10]. Guide cane is another type of cane for blind people. It is useful for people with a lower level of visual function to avoid obstacles, similarly to long cane but different in the way of holding the guide cane diagonally across the body and use it to find obstacles in front of them such as kerbs and steps [10].

B. Related Works

There are several similar works identified and studied to understand the research area better. Each work implemented several different functions that help in system improvement. There are several functions to be noted as listed below:

I. Ultrasonic sensor
II. IR sensor
III. Monocular camera
IV. RF transmitter
V. Water sensor
VI. Speech warning message

Table 1 below shows the comparison between the works and the implemented functions based on the above list:

TABLE 1. Comparison between related works

Related Works	I	II	III	IV	V	VI
Intelligent Cane [11]	✓		✓	✓		
Smart Walking Stick [12]	✓		✓	✓		
Effective Fast Response for Blind People [13]	✓	✓			✓	✓
Smart Cane for Visually Impaired [14]	✓				✓	✓

It should be noted that the smart cane designed in this study is unique in a way, which proposed an additional function which is the GPS location tracker that allows the location of the cane to be determined via the Blynk App.

Nonetheless, it was not enough for visually impaired because traditional cane does not provide information about obstacles or water puddles thus cannot give the high guarantee to protect themselves and being away from all level of obstacles [15]. To address this, a few smart canes was proposed. However, a little study proposed a smart cane by integrating obstacle detection, water detection and GPS module to monitor the location of visually impaired.

3. SYSTEM DESIGN AND DEVELOPMENT

This section describes the design and development of AAMS. The section is divided into three sub-sections; (i) the flow of the proposed system; (ii) the hardware used in the proposed system; and (iii) the software configuration.

A. The flow of the Proposed System

Figures 1 and 2 illustrate the process of the proposed smart cane.

The process started when the stick used by visually impaired was initiated. Once the visually impaired reaches at least 50 cm distances from the obstacles, the buzzer will produce a "*beep*" sound to alert the user that there are obstacles in front of them. In the case of the visually impaired approaching water puddle on the road and the water, sensor touch the water, the buzzer will also be triggered.

The GPS track the location of the visually impaired via Blynk application. In the Blynk application, information on location such as latitude and longitude and also the map are displayed in the application.

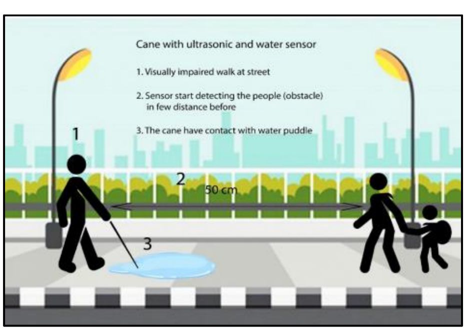

Figure 1 Overview of the proposed smart cane

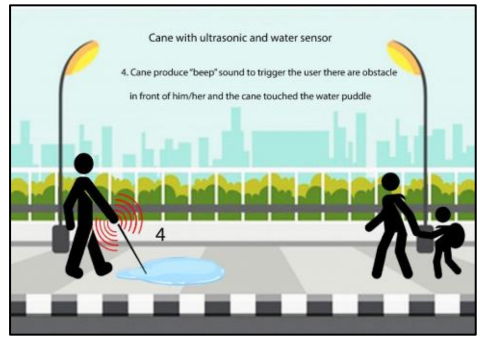

Figure 2 Overview of the proposed smart cane

Next section discussed the hardware required for this study.

B. Hardware Setup

Node-MCU or in other terms known as ESP8266 module is a particularly adept wireless programmable microcontroller board. The ESP8266 Wi-Fi board is a system-on-chip (SOC) with an integrated TCP/IP protocol stack that can give some secondary microcontroller access to your Wi-Fi network. The ESP8266 board is capable of either hosting an application or offloading all Wi-Fi networking functions from another application processor. Therefore, this is more suitable to be used as a sensing node that is capable of sensing the data from various wirelessly connected Internet of Things (IoT) sensor nodes and send data to the central server [16]. ESP8266 is aimed for wireless location-aware devices, wireless positioning systems signals and so forth. The process and transfer information to the web server can be used from Node-MCU so that the smartphone can access the information.

Ultrasonic distance sensor emits a series of supersonic pulses and waits for echo pulses to be detected. Since the speed of sound is constant with the value of 340.29 m/s, the time elapses between the transmitted signal and the received signal can be measured and so the distance of the object can be determined. The sensor consists of a trig pin, echo pin, out pin, integrated power supply pin or '*vcc*' and '*gnd*' the ground pin. However, in this project, pins used were trigged pin, echo pin, '*vcc*' and '*gnd*'. The sensor works in a manner starting from the echo that will spread the sonar around the area. Once it hit the object, it will return to the sensor, and trig pin will read for further action. The HY-SRF05 used 5V of power on the breadboard. The sensor was able to read distances up to 450 cm. For this project, the distance setup was in the range of 0 to 50 cm for triggering the buzzer.

Water sensor work to detect the presence of the water, which consisted of three pins which were S, positive pin, and negative pin. S is the pin where the output goes to an analogue signal on Node-MCU. On the other hand, the positive pin or 'vcc' works as a power supply, and the negative pin is the 'gnd' or ground pin. Water sensor only required 3.3V without any support components in between them. Generally, the water sensor functions to read the level of water. For this project, the water level does not matter. The water sensor generally is capable of reading the water level. However, in this project, the focus is on the presence of water, which means that when the sensor able to touch the water, the buzzer will be triggered.

A passive buzzer requires an AC signal to make a sound. It is like an electromagnetic speaker where a changing input signal produces the sound rather than producing a tone automatically. In this study, the buzzer was used to trigger the user by producing '*beep*' sound. The buzzer consisted of two pins which are positive and negative. The buzzer used the '*D1*' pin on Node-MCU for the positive pin and '*D2*' for the negative pin with two of the jumper wire.

The Global Positioning System (GPS) could be a satellite-based route framework made up of at least 24 satellites. GPS works in any climate conditions, anyplace within the world, 24 hours a day, with no membership expenses or setup charges. The NEO-6 module series, which is a family of stand-alone GPS receivers featuring the high-performance u-blox 6 positioning engine was used in this study. These flexible and cost-effective receivers offer numerous connectivity options in a small 16 x 12.2 x 2.4 mm package. GPS has four pins in total, which are '*vcc*', '*rx*', '*tx*' and '*gnd*'. In this project, '*vcc*' pin connected to 3V3 pin, '*rx*' works to receive data in which it is connected D1 and '*tx*' connected to D2 works to transmit data while '*gnd*' is ground.

Fritzing software then was used to visualize the schematic diagram of the study. Figure 3 illustrates the schematic diagram of the study.

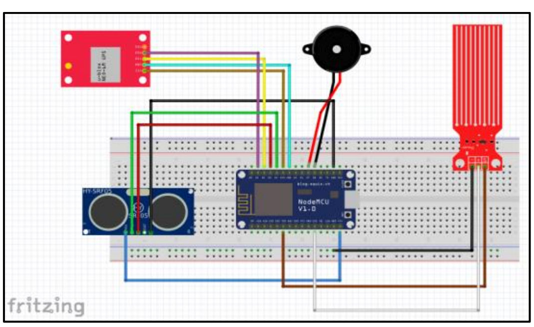

Figure 3 Schematic diagram of the proposed study

The sensor consists of the trig pin, echo pin, out pin, integrated power supply pin or '*vcc*' and '*gnd*' the ground pin. However, in this project pins used were trig pin, echo pin, '*vcc*' and '*gnd*'. The sensor works in a manner starting from the echo that will spread the sonar around the area. Once it hit the object, it will return to the sensor, and trig pin will read for further action. The HY-SRF05 used 5V of power on the breadboard. The sensor was able to read distances up to 450 cm. For this project, the distance used was in the range of 0 to 50 cm for triggering the buzzer.

Water level sensor consisted of three pins which were S, positive pin, and negative pin. S is the pin where the output goes to an analog signal on Node-MCU. On the other hand, the positive pin or '*vcc*' functions as power supply and the negative pin are the '*gnd*' or ground pin. Water level sensor only required 3.3 V without any support components in between them. The water level sensor generally is capable of reading the water level. However, as this project focused on the presence of water, as the sensor able to touch the water, the buzzer will be triggered. The buzzer used the '*D1*' pin on Node-MCU for the positive pin and '*D2*' for the negative pin with two of the jumper wire.

C. Software Configuration

In order to start the programming process, the Node-MCU had to be defined first of its pin that connected to the component as in Figure 4. As for the ultrasonic sensor and water sensor, both did not require program library. The first step is to define the pins for all components connected with Node-MCU, which are ultrasonic sensor, water sensor and buzzer. For example, the ultrasonic sensor trig pin is connected to the D4 pin on Node-MCU - as the similar goes for the other components. The void setup function starts to initiate variables and pin modes, either input or output. The setup function will only run once for each power-up of the Node-MCU. Serial begin sets the data rate in bits per second. The higher the rate of data, the faster the process of Node-MCU. For this project, it was set to data rate 115200 bauds which to make the processing for the board rapid.

```
// Define pins for ultrasonic, buzzer and water sensor
int const trigPin = D4;
int const echoPin = D3;
int const piezoPin = D1;
int analogInPin = A0;


void setup()
{
  pinMode(trigPin, OUTPUT); // trig pin will have pulses output
  pinMode(echoPin, INPUT); // echo pin should be input to get pulse width
  pinMode(D1, OUTPUT); // buzz pin is output to control buzzering
  pinMode(D2, OUTPUT); // buzz pin is output to control buzzering
}
```

Figure 4 Code snippet

In this case, source code for GPS cannot be integrated with ultrasonic and water level sensor sketch. This was due to the ultrasonic sensor, water level sensor and GPS module cannot have two parallel processes. The solution have been taken to solve this problem was by using two Node-MCU of which one was for ultrasonic sensor, and water level sensor and the other one for the GPS module. Figure 5 below depicts the libraries for the GPS module that need to be used in order to make it work.

```
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#define BLYNK_PRINT Serial
#include <ESP8266WiFi.h>
#include <BlynkSimpleEsp8266.h>
```

Figure 5 Code snippet for GPS libraries

The next part was defining the pins that were used to connect the GPS. RXPin was connected to the D1 pin on the NodeMCU while TXPin was connected to D2 pin. The rest code snippet in Figure 6 was for connection to Wi-Fi hotspot, GPS and Blynk App. Connection for all these was necessary in order to make the GPS worked without a glitch.

```
static const int RXPin = 4, TXPin = 5;   // GPIO 4=D2(conneect Tx of GPS) and GPIO 5=D1(Connect Rx of GPS)
static const uint32_t GPSBaud = 9600; //if Baud rate 9600 didn't work in your case then use 4800

TinyGPSPlus gps; // The TinyGPS++ object
WidgetMap myMap(V0);  // V0 for virtual pin of Map Widget

SoftwareSerial ss(RXPin, TXPin);  // The serial connection to the GPS device

BlynkTimer timer;

float spd;       //Variable  to store the speed
float sats;      //Variable to store no. of satellites response
String bearing;  //Variable to store orientation or direction of GPS

char auth[] = "10fe0f02e64e45ccb5b1a1c1aeab650b";              //Your Project authentication key
char ssid[] = "MyA7";                                        // Name of your network (HotSpot or Router name)
char pass[] = "ahmadnazri567";                                   // Corresponding Password


unsigned int move_index;         // moving index, to be used later
//unsigned int move_index = 1;       // fixed location for now
```

Figure 6 Code snippet for GPS setup

The primary process for this program is the loop section. In this section, the loop function will check the pin serially and allows the developer to change and respond to the pin. It controls the behavior of Node-MCU by giving the task of what it should do. The sequence of the loop started with declaring all variables in order to calculate duration, distance and water level.

The loop would process the sensor by giving it a condition to carry out a specific task. In this project, the ultrasonic sensor would activate the buzzer if the distance is in the range of 0 to 50 cm. The same goes to the water sensor, and it would activate the buzzer as well if the value read by the sensor is greater than 0, which means the sensor came into contact with water.

Since this project was using two different sensors, there will be two 'if' statement in one loop. Firstly, for ultrasonic sensor, the distance was set to less than 50 cm and more than 0 cm then the buzzer will be triggered with frequency 10000 Hz or else buzzer will return 0 Hz. Meanwhile, the same goes to water sensor if the value read by the sensor is greater than 0 which means the sensor successfully detect the water, the buzzer will be triggered, or if there is no water, the buzzer will not be triggered.

Blynk application was used to store the longitude, latitude and display all those values. The purpose of using the GPS module was to provide a location of the visually impaired for the family. This function can be useful when the visually impaired are in harm. If the GPS can detect location, GPS will send the longitude, latitude, and the number of speed to the Blynk App. Figure 7 illustrates how the data was displayed in the Blynk application.

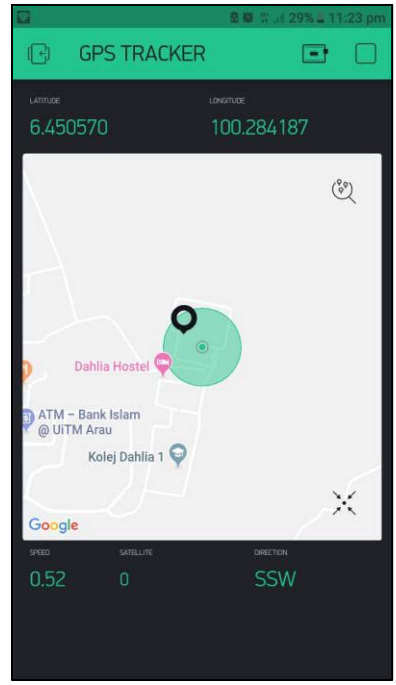

Figure 7 Data displayed in Blynk application

4. RESULTS AND DISCUSSION

Functionality testing was carried out to determine the effectiveness of the proposed study. Ten participants took part in the functionality test, which comprises of two parts. In the functionality testing, there were two parts of the. The first part of the testing involved the detection testing with the ultrasonic sensor. The second part was the water detection testing with a water sensor. In these testing, both hardware were exposed to conditions and approximate readings were taken for measurement Figure 8 illustrates the path the respondents went through for functionality testing.

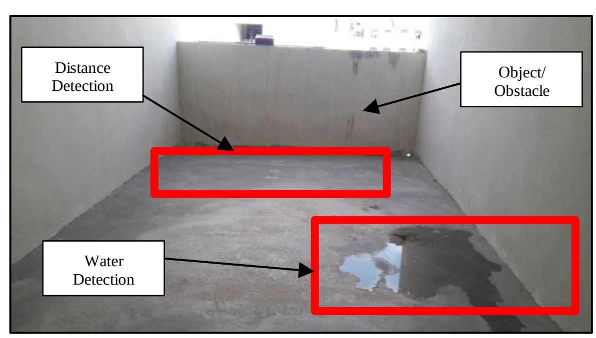

Figure 8 Illustration of the environment for the functionality test

A. *Obstacle Detection Test*

The sensor was tested when participants walked with the beginning distance between object was 100 cm, 80 cm, 60 cm and lastly 50 cm.

As mentioned earlier, the sensor was set to detect the obstacles within 50 cm. As illustrated in Table, when the participants walk from 100 cm to 60 cm, the sensor was unable to detect the object in front of them. When they reached the distance 50 cm, the sensor was able to detect an object but not particularly accurate. This was due to different ways of participants walked. In-depth, since the participants were imitated as blind people and their eyes were blindfolded, they did not walk in a straight direction towards the object.

By having this test, the project can have an imprecise distance value to be set in the Arduino sketches. After considering the project's constraints with more calculation for sensor best distance to work with, it was decided for the sensor to start its reading in less than 50 cm inclusively with an obstacle in front at the sensor. **Error! Reference source not found.** visualizes how the respondents have been tested for distance detection.

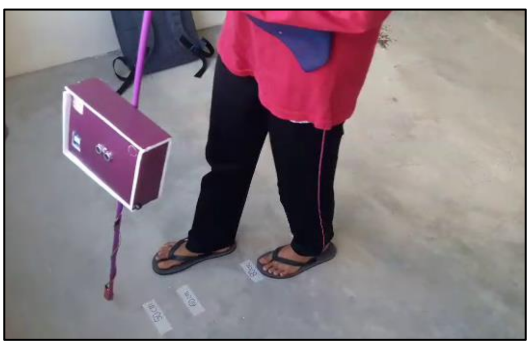

Figure 9 Obstacle detection test

TABLE 2. Results of the obstacle testing

Distance between obstacle	Detect	Not Detect
100 cm		✓
80 cm		✓
60 cm		✓
50 cm	✓	

B. Water Puddle Detection Test

For the water level sensor testing, the level of water was not the issue since this project focused on to test the presence of water. The way to test this sensor was similar to the ultrasonic sensor. For this sensor, the researcher created a water puddle by pouring some water on the floor along the path for participants to walk through, as illustrated in Figure 10.

Figure 10 Obstacle detection test

The sensor was tested when participants walk on the path. Once the sensor touches the water puddle, the buzzer triggered. Right after the sensor was out of the water, the buzzer stopped beeping. Table 2 illustrates the conditions set up for water puddle detection testing.

TABLE 3. Results of the water puddle testing

Presence of water	Yes	No
With water	✓	
Without water		✓

Seven out ten participants managed to detect the water puddle when they walk through it. However, three of the participants was not able to detect water puddle. A few factors that lead that was, the participants did not hold and touch the proposed smart cane when they walked through the water puddle. The other factor was that the floor surface was rampant, of which the water cannot stagnate like a water puddle. This condition caused the sensor failed to detect water accurately and consistently.

5. CONCLUSION

In conclusion, this study has proposed another alternative to assist the visually impaired by integrating three different devices, which are obstacle detection, water detection and also the GPS module to monitor the visually impaired location.

In future research, we will focus on improving the prototype by adding more ultrasonic sensor in every angle so that it able to detect obstacles at a low and high angle using detection algorithm such as Artificial Neural Network based on multiple parameters from different sensors, improve busser sound, integrate 4G/5G module to send information continuously to a server. This can be used to track accidents and to create an obstacles database, which can be used by visually impaired and develop a prototype that is compatible in a real-life situation where it should be more lightweight and durable.

Moreover, AI and IoT (AIoT) can also be incorporated to enhance the proposed prototype, i.e. may offer an insight into which processes are redundant and time-consuming, and which tasks can be fine-tuned to increase efficiency.

REFERENCES

[1] Bourne, R. R., Flaxman, S. R., Braithwaite, T., Cicinelli, M. V., Das, A., Jonas, J. B., & Naidoo, K. (2017). Magnitude, temporal trends, and projections of the global prevalence of blindness and distance and near vision impairment: a systematic review and meta-analysis. *The Lancet Global Health*, *5*(9), e888 e897.

[2] Riazi, A., Riazi, F., Yoosfi, R., & Bahmeei, F. (2016). Outdoor difficulties experienced by a group of visually impaired Iranian people. Journal of current ophthalmology, 28(2), 85-90.

[3] Kim, S. Y., & Cho, K. (2013). Usability and design guidelines of smart canes for users with visual impairments. *International Journal of Design*, *7*(1), 99-110.

[4] World Health Organization. (2018). *WHO world report on vision*. Retrieved from www.who.int/blindness/vision-report/Consultation-draft-World-report-onvision.docx

[5] Boyce, T., & Boyce, T. (2011). Falls-costs, numbers and links with visual impairment. *RNIB. Also see Age UK and the College of Optometrists: The Falls Omnibus Survey*.

[6] Lacey, G., Dawson-Howe, K. M., & Vernon, D. (1998). *Personal Adaptive Mobility Aid for the Infirm and Elderly Blind*.

[7] Lloyd, J. K., Budge, R. C., Stafford, K. J., & La Grow, S. (2009). A focus group discussion on using guide dogs. *International Journal of Orientation & Mobility*, 2(1), 52-64.

[8] Lloyd, J. K., La Grow, S. J., Stafford, K., & Budge, R. C. (2008). The guide dog as a mobility aid part 2: perceived changes to travel habits. *International Journal of Orientation & Mobility*, *1*, 34-45

[9] Tennessee Council of the Blind. (2009). *the history of the white cane*. Retrieved October 13, 2018, from http://www.acb.org/tennessee/white_cane_history.html

[10] Forth-Ports. (2011). *Getting About*. Retrieved from http://www.tobyfreeman.com/projects/forthside/gettingAbout.htm

[11] Lakshmi S, Priya & Kalpana. (2014). Intelligent white cane to aid visually impaired. International Journal of Advanced Research in Electronics, Communication & Instrumentation Engineering and Development, 2(2), 2933.

[12] Gbenga, D. E., Ibrahim, A., S., & Adekunle, A. L. (2017). Smart Walking Stick for Visually Impaired People Using Ultrasonic Sensors and Arduino. ISSN International Journal of Engineering and Technology (IJET) ISSN (Print International Journal of Engineering and Technology, 9(5), 2319–8613. https://doi.org/10.21817/ijet/2017/v9i5/170905302

[13] Nada, A., Mashelly, S., Fakhr, M. A., & Seddik, A. F. (2015, April). Effective fast response smart stick for blind people. In Proceedings of the second nternational Conference on Advances in bio-informatics and environmental engineering–ICABEE.

[14] Sushrut A., Hitesh K., Ishita J., Vikas G. B. (2018). Smart cane for visually impaired people. International Journal of Advance Research, Ideas and Innovations in Technology, 4(2) www.IJARIIT.com.

[15] Alshbatat, N., & Ilah, A. (2013). Automated Mobility and Orientation System for Blind or Partially Sighted People. *International Journal on Smart Sensing & Intelligent Systems*, *6*(2).

[16] Patnaikuni, D. R. P. (2017). A Comparative Study of Arduino, Raspberry Pi and ESP8266 as IoT Development Board. *International Journal of Advanced Research in Computer Science*, *8*(5), 2350–2352.

N.M.A.Nazri is a research student from the Faculty of Computer and Mathematical Sciences and is under guidance and direction from the researchers of Applied Computing and Technology Research Group.

Associate Professor Ts. Dr Shukor Sanim Mohd Fauzi is a Deputy Rector (Research and Industrial Linkage) at UiTM Perlis Branch, and also a faculty member of Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Perlis Branch, Malaysia. Previously, he has held Visiting Fellow position at Universitas Airlangga (2018), and Visiting Researcher position at Universitas Islam Riau (2018). He received Diploma in Computer Science and Bachelor Science (Hons) specializing in Information Systems Engineering from the Universiti Teknologi MARA, and Master of Science (Computer Science - Real Time Software Engineering) from the Centre for Advanced Software Engineering, Universiti Teknologi Malaysia. He then obtained his PhD in Software Engineering from the University of New South Wales (UNSW), Australia and in the working group of Data61 (formerly known as Software Systems Research Group), Commonwealth Scientific and Industrial Research Organisation (CSIRO) which is based at the National ICT Research Centre Australia (NICTA), Australian Technology Park (ATP). His area of specialization includes software engineering, empirical software engineering, mining software repository, social network analysis, socio-technical congruence, computer-supported collaborative work, and software process. He has received more than 16 research grants (internal and external grants) totalling over RM1,000,000. He has published more than 100 scientific publications and has won more than 50 medals at a national and international exhibition. He also is the editor for 5 books including “Software Process Improvement and Management: Approaches and Tools for Practical Development”.

R.A.J.M.Gining is now serving as a lecturer at the Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Perlis Branch, Malaysia. He received his Diploma in Computer Science and Bachelor Science (Hons) specializing in Information Systems Engineering from the Universiti Teknologi MARA, and Master of Science in Cloud Computer from Newcastle

University, United Kingdom. His research interest includes System development, IoT and machine learning. He is also a researcher of Applied Computing and Technology Research Group.

T.R. Razak currently works at Universiti Teknologi MARA, Perlis Branch, Malaysia as a member of Faculty of Computer and Mathematical Sciences. He received Bachelor of Information Technology (Hons) specializing in Artificial Intelligent from the Universiti Utara Malaysia, and Master of Science (Intelligent Systems) from the Universiti Utara Malaysia. He then obtained his PhD in Computer Science from the University of Nottingham, United Kingdom. While pursuing his PhD, he was a member of Intelligent Modelling & Analysis (IMA) and Laboratory for Uncertainty in Data and Decision Making (LUCID) research groups. He is currently a member of the IEEE-CIS Task Force on Explainable Fuzzy Systems. His research interests centre around the field of Intelligence Systems, Fuzzy Logic Systems and Hierarchical Fuzzy Systems, Decision Support Systems and Interpretability.

M. N. F. Jamaluddin received Bachelor of Computer Science (Hons) and Master of Science (Computer Science) from Universiti Teknologi MARA. After the obtainment of his master's degree, he joined Faculty of Computer and Mathematical Sciences, Universiti Teknologi MARA, Perlis Branch. He is currently served as a senior lecturer and teaching programming related courses. His research interest is majorly in Machine Learning with projects related to classifications and optimizations. He is also a researcher of Applied Computing and Technology Research Group.