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Microcontroller Based Obstacle Detection and Location Tracker Using Smart Stick System for Visual Impairment People

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Abstract: Visually impaired individuals face challenges in identifying obstacles while walking on the streets, making it a dangerous task. A proposed solution to this problem is a smart stick that can help them navigate their surroundings. In this paper, we suggest the use of a smart stick that is equipped with a pair of ultrasonic sensors. This project is designed to assist blind individuals in overcoming obstacles. This stick will have a sensor installed in it that will detect any item or person in front of it that have different positioning to detect obstacles at different angle. The ultrasonic sensor 1 is programmed for sensing distance at 80 cm and positioned at waist level while ultrasonic sensor 2 is programmed for sensing distance at 50 cm positioned at ankle level for detecting lower part of obstacles. When one of the ultrasonic sensors detects obstacles via transmitting sound wave, it will trigger the output component such as buzzer and disc vibrating motor which alert the user to be go on another route where there is no obstacle in front of them. The stick also embedded with navigation tracking system where the guardian can locate real-time location the stick user by using an application called as Blynk with the help of GPS module and WIFI. As a conclusion, visually impaired individuals in becoming aware of obstacles or uneven surfaces that may cause harm in their surroundings. This can help to reduce the risk of injuries and enhance their ability to navigate their environment.

Keywords: Smart Blind Stick, Navigation Tracker, Blind People, Visual Impaired, Ultrasonic Sensor

1. Introduction

Visually impaired individuals are those who have difficulty recognizing small details with healthy eyes. Those with a visual acuity of 6/60 or a horizontal visual field of 20 degrees or less are considered

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blind. A survey by the World Health Organization (WHO) in 2011 estimates that 1% of the global population is visually impaired, with 7 million fully blind and 63 million with low vision [1]. The main challenge for blind individuals is navigating their environment, and they often require assistance from those with healthy eyesight. As described by WHO, 10% of the visually impaired have no functional eyesight at all to help them move around without assistance and safely. Vision is a crucial aspect of human physiology, as 83% of the information humans receive from the environment is through sight. The 2011 statistics by the World Health Organization (WHO) estimate that there are 70 million people in the world living with visual impairment, 7 million of which are blind and 63 million with low vision [2].

The most conventional and oldest mobility aids for persons with visual impairments are characterized by many limitations. Some inventions also require a separate power supply or navigator which makes the user carry it in a bag every time they travel outdoors. These bulky designs will definitely make the user exhausted. To address these limitations, this research aims to design an assistive technology for visually impaired individuals that can detect obstacles and provides alternative routes for the blind. The technology will also alarm the user through vibration to determine the obstacles direction sources. Furthermore, this project proposes a new technique for designing a smart cane to help visually impaired people navigate their environment. The most conventional and oldest navigation aids for persons with visual impairments are the walking cane (also called white cane or stick) and guide dogs which are characterized by many imperfections. The most serious limitations of these aids are fundamental skills and development phases, range of motion, and relatively minor information delivered [3]. The design also come out with an Internet of Thinks application where the guardian of the visually impaired person can locate the whereabouts of the blind cane user via NodeMCU ESP8266 and GPS module as it hardware for navigation tracker system.

Moreover, in the obstacle detection domain, ultrasonic sensors are used due to their advantages compared to other detection sensors such as infra-red sensors, capacitive sensors, etc. In conclusion, this research aims to improve the mobility and independence of visually impaired individuals by designing a smart cane that can detect obstacles and provide alternative routes, alarm the user through vibration to identify obstacle sources, and help the user locate their cane. With the use of electronic components and sensors, it aims to solve the limitations of traditional mobility aids and provide a more efficient means of navigation. The proposed technology can also improve the safety and security of visually impaired individuals by allowing their guardians to track their whereabouts. The use of ultrasonic sensors in obstacle detection is an efficient and reliable method that can be used to improve the overall experience of visually impaired individuals in their daily lives [4].

2. Methodology

2.1 Smart blind stick with obstacle detection system and navigation tracking system

In this project, two ultrasonic are connected and being controlled to one main microcontroller which is Arduino UNO. Based on the figure 1 below, it begins by turning on the Arduino uno which will initiate both ultrasonic 1 and ultrasonic 2. Both sensors have different distances of detecting obstacles due to the reason of different positioning as the ultrasonic sensor 1 is positioned to detect obstacle at the user's waist level while ultrasonic sensor 2 is positioned at ankle level to detect lower obstacles, ramps or steps, etc. Ultrasonic 1 are program to detect obstacle at 80 cm and below while ultrasonic sensor 2 are programmed to detect obstacle at 32 cm and below. Ultrasonic sensor will transmit sound wave based on the fixed distance in which when the transmitted signal is detecting obstacle, it will transmit back to the sensor, and it will trigger buzzer and vibrating motor to turned on in which indicates the presence of obstacle in front of the sensor. The users will walk sideways where there are no obstacles present in front of them. Furthermore, when ultrasonic sensor 1 detects obstacle, it will trigger vibration motor and buzzer to turned on while ultrasonic sensor 2 only triggered buzzer to turned on. This is because the user can alert and differentiate whether the obstacles are at lower level or on its waist level at in front of them.

As for location tracker system on Figure 1 and Figure 2, the NodeMCU and GPS module will initially read the user data that had been accessed on Blynk applications. If the data of the user is in the database, it will instantaneously read the GPS data including latitude, longitude, speed, satellite and bearing. If the information of the location is successfully acquired, it will immediately send the GPS data to the Blynk applications. The application will be updated every minute (the notification can be change following the user's need) or it will send notification when the value of latitude and longitude are changing which helps the user detects faster the location of the patient who use the smart blind stick. This app usually used by the guardian of the blind or visual impaired to monitor the patient on their whereabout.

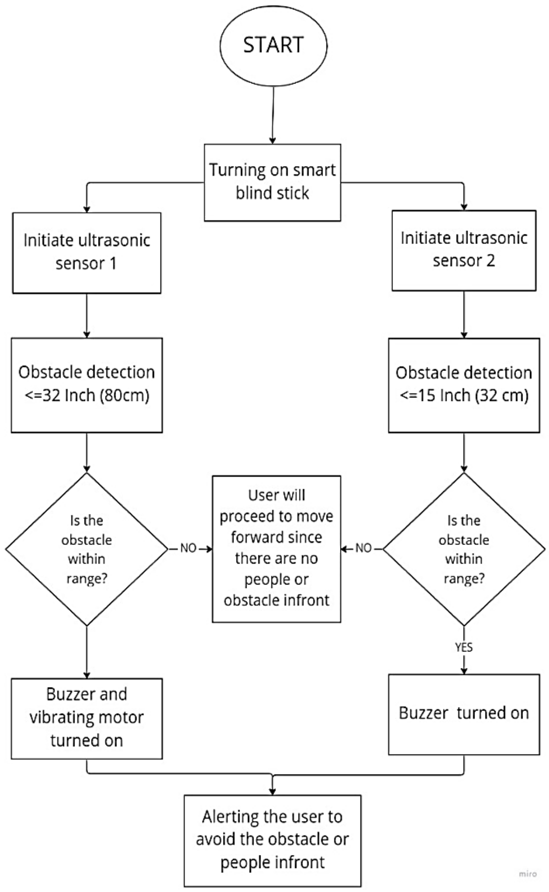

Figure 1: Flowchart of obstacle detection system

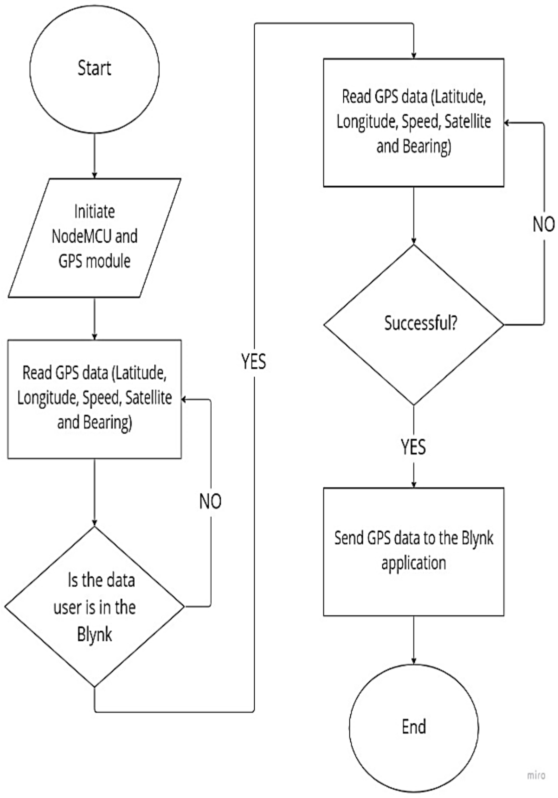

Figure 2: Flowchart of GPS tracking system via Blynk

2.2 Calculation of the transmitted wave from ultrasonic sensor

During observation ultrasonic sensor that were used has different value for distance to transmit signal wave for obstacle detection. Ultrasonic wave 1 was programmed to detect at 32 inches (81.3cm) of distances while for ultrasonic sensor 2 was program the value of distance at 15 inches (38cm) of distances. Each of the ultrasonic sensors has their own task in which ultrasonic sensor 1 is for detect obstacle that are at waist level while ultrasonic sensor 2 is for detecting obstacle at the level of the leg ankle. Sound travels at a speed of around 340 meters per second. This equates to around 29.412s (microseconds) per centimeter. After that, use the following formula to calculate the distance travelled by sound: Distance = (Time x Sound Speed) / 2. Due to the sound wave must travel back and forward between, the "2" is included in the calculation.

$$Distance = \frac{Sound\ Speed\ (\frac{km}{h})\ x\ Time}{2} \quad \text{(Eq. 1)}$$

$$Sound\ speed = 340\ Meter\ per\ second \quad \text{(Eq. 2)}$$

2.3 Materials and method

In hardware development, there are 4 main parts in order for this project to be completed, In this system, Arduino Uno is the main controller which control the input and output of the pin based on the programmed that had been verified and uploaded from the Arduino IDE. Secondly is ultrasonic sensor, which is used for transmitting sound waves to be reflected from the object and transmit back the data as is detects the obstacles. Besides that, buzzer and vibrating motor will act as the output of the system where it will trigger when the ultrasonic sensor detects obstacle within its distances. The user will be informed by the output saying that the obstacle is nearby and needs to be careful.

The smart blind stick system project's hardware and software development components can be divided into two groups. The hardware development section includes all of the hardware parts utilized in this project. Among the components are an ultrasonic sensor, an Arduino uno microcontroller, a vibrating motor, and a battery/power supply. ThinkerCAD are used to produce software for creating circuit designs, GPS tracker by using Blynk application, while the Arduino IDE is used for coding.

2.3.1 TinkerCAD simulation

The circuit design of an obstacle detection system, as shown in Figure 3, was created using the TinkerCAD electronic software. The system features 2 ultrasonic sensors for obstacle detection, an Arduino Uno microcontroller, a buzzer, and a disk vibration motor as an alarm output. The TinkerCAD software is compatible with Arduino IDE programs, making it easier to simulate the circuit for distance testing. The green dots on the ultrasonic sensor indicate the distance that will be used to test the threshold distance, which will trigger the buzzer and vibration motor when the specific range is reached.

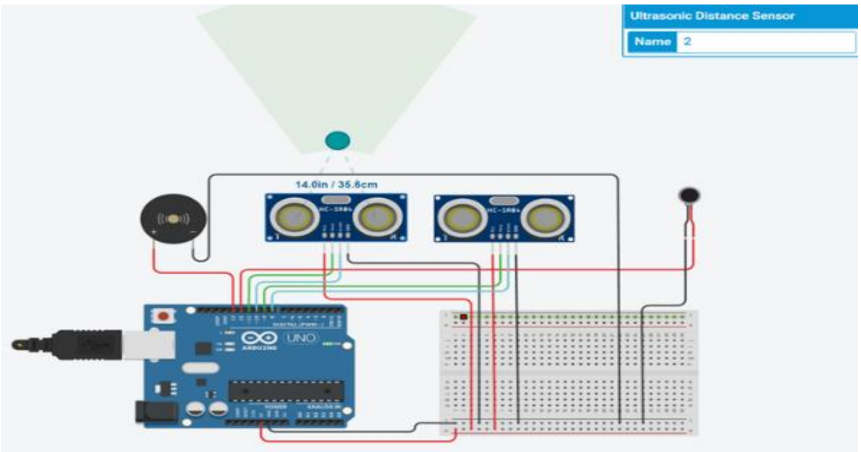

Figure 3: Running the simulation on TinkerCAD using source code from Arduino IDE software

Figure 4 shows the connection of the components on microcontroller Arduino Uno for testing the capability of obstacle sensor using two ultrasonic sensors for specific distance of an object. This experiment is conducted for at different distance sensing trial by trial to see whether the ultrasonic sensor could sense obstacle farther away.

In theory, the ultrasonic sensor HC-SR04 can measure from 10 cm to 400 cm maximum distances which are quite far for the sensor to transmit its sound wave. In the figure 3, ultrasonic sensor also consists of 4 pins which are Vcc (power), Trig pin (trigger), Echo pin (receive) and lastly GND (ground). VCC and GND are connected to the Arduino's 5V and GND pins, respectively, while Trig and Echo are connected to any digital Arduino pin. We send the ultrasonic wave from the transmitter using the Trig pin, and we listen for the reflected signal using the Echo pin.

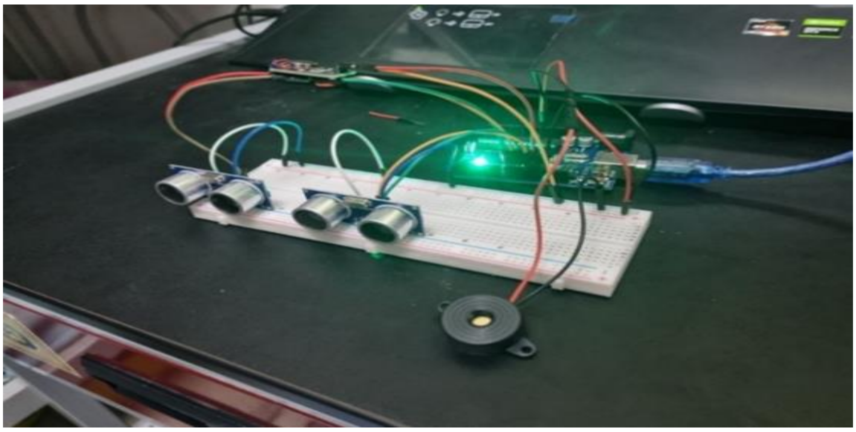

Figure 4: Testing the circuit by uploading the Arduino IDE code into UNO

While on the other hand, Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. Arduino Uno is the medium version in the Arduino family such as Arduino nano which has smaller size and Arduino Mega that has the biggest size. Uno is one of the popular microcontrollers due to its flexibility with both software and hardware in the system. This microcontroller has 5V operating system, but its input voltage can be in a range of 7V to 12V. maximum current rating for this microcontroller is 20mA per pin. As a result, the load attached to its pins should not drain any further. In Arduino Uno, the size of the flash memory is 32kb and has 2KB of SRAM memory. The clock speed of this Arduino is 16MHz and has EEPROM with a size of 1KB.

2.3.2 Blynk Application

Blynk is an Internet-of-Things platform for iOS or Android smartphones that allows users to remotely operate devices like Arduino, Raspberry Pi, and NodeMCU. Using this programme, you can compile and provide the right address on the various widgets to construct a graphical interface or human machine interface (HMI). For this project, Blynk software is used to locate the blind or visual impaired person whereabout which will show the latitude and longitude of recent location and automatically shows in the map.

Figure 5 shows the interphase of the Blnyk application that will be used to navigate and check the recent location of the blind stick. In this interphase consist of latitude, longitude, speed, satellite and bearing and the data acquire are from GPS module that connected with the NodeMCU esp8266. Microcontroller NodeMCU esp8266 are used for its compatibility with WIFI to synchronise with the Blynk application. So, the data gathered from the GPS module will automatically.

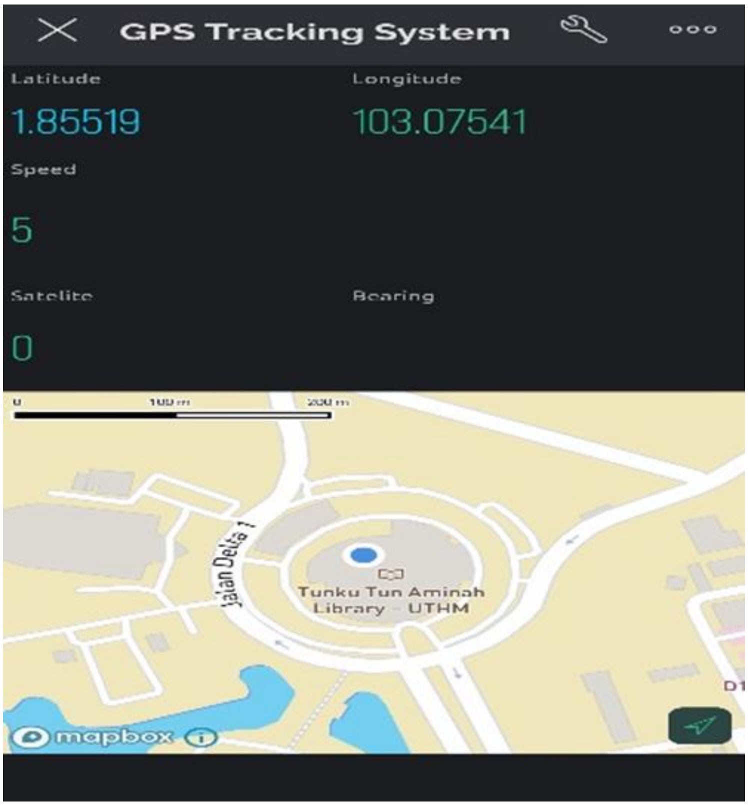

Figure 5: setting up Blynk application for GPS tracking system

3. Results and Discussion

The smart blind stick obstacle detection is expected to fulfil all the goals and requirement which could detect the obstacle by using the ultrasonic sensor as a detector while buzzer and vibrating motor will act as output which produce sound and vibration when obstacle detects by the sensor. A collection of data will be collected by testing the smart blind stick on the examinee using multiple kinds of objects, and the participants will verify whether the sensor can recognize objects within its sensing area.

3.1 System overview

The primary goal of creating this project is to be portable, with low power consumption, and low cost with an obvious short response time. The importance of this study is to help blind and visually impaired people to be able to be aware of their surroundings from the obstacles or uneven steps that could harm them. Furthermore, this effort could reduce the risk of injuries and loss of the patient when they are going out to do their daily live activities with the help of an application that could track their location. Based on the project, ultrasonic sensor 1 was placed in the box with a 90 degrees placement to detect people or obstacles at waist level while ultrasonic sensor 2 was placed at ankle level with a 45 degrees placement. Furthermore, ultrasonic sensor 1 had been programmed to detect within the range below 80 cm or equal while ultrasonic sensor 2 are coded within 32 cm and below of distance sensed. Figure 6 shows the front view of the developed device.

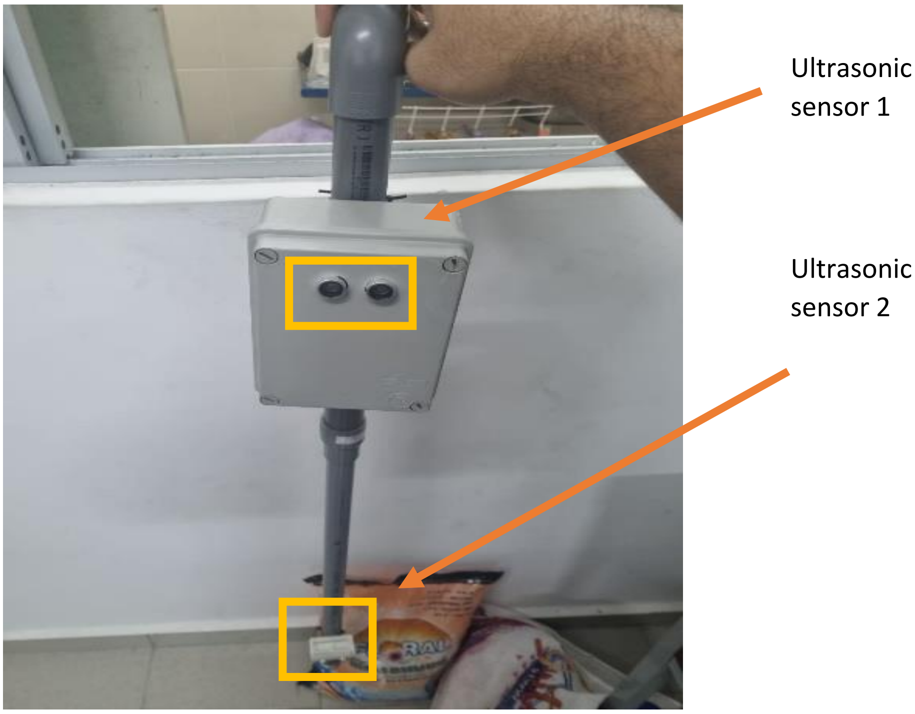

Figure 6: Project's front view

3.2 Results

3.2.1 Data analysis (distance calculation from the ultrasonic sensor)

In this project, the distance was observed during simulation testing and during the final product. The table below shows the maximum value of distances that had been programmed (simulation) toward both ultrasonic sensors which triggered vibrating motor and buzzer that are observed from the simulation and from the actual distances. Relative error was calculated for each time as the expected value was changed 10 times. To calculate the ratio of the absolute error of the measurement to the actual measurement. The formula for calculation to get the relative error is as follows.

Table 1: Observing the testing of ultrasonic 1 and ultrasonic 2 by simulation and actual experiment

No	Ultrasonic sensor 1 (distance)			Ultrasonic sensor 2 (distance)		
	Measurement (simulation)	Actual reading	Relative error (%)	Measurement (simulation)	Actual reading	Relative error (%)
1.	8 cm	7.8 cm	0.02	5 cm	4.9 cm	0.02
2.	16 cm	15.8 cm	0.01	10 cm	10.2 cm	0.02
3.	24 cm	24.3 cm	0.01	15 cm	14.5 cm	0.03
4.	32 cm	30.6 cm	0.04	20 cm	20.7 cm	0.04
5.	40 cm	37.4 cm	0.07	25 cm	24.3 cm	0.03
6.	48 cm	46.5 cm	0.03	30 cm	27.6 cm	0.08
7.	56 cm	53.8 cm	0.04	35 cm	33.7 cm	0.04
8.	64 cm	61.9 cm	0.03	40 cm	37.8 cm	0.06
9.	72 cm	68.5 cm	0.05	45 cm	41.3 cm	0.08
10.	80 cm	75.7 cm	0.05	50 cm	46.4 cm	0.07

3.2.1 Obstacle detecting review.

Table 2 showing the review from 10 participants that willingly test the smart blind stick to detects different types of obstacles at indoors and outdoors. During the experiment, the participants will give their response toward the pros and cons of the stick which could be an advantage to upgrade the smart blind stick in the near future.

The ultrasonic sensor 1 working distance is being programmed at 32inch (80cm) while ultrasonic sensor 2 is at distance of 15inch (38cm).

Table 2: Observation for the data and review from participant response

Number of participants	Gender	Weight (kg)	Height (m)	Review
Person 1	Male	95	1.70	Works okay but some obstacle below feet cannot be detected.
Person 2	Male	84	1.70	Both buzzer and vibrating sensor activated when there is no obstacle in front of sensor.
Person 3	Male	58	1.84	There is delay on buzzer when ultrasonic sensor detects obstacle.
Person 4	Male	82	1.68	Buzzer sound does not loud enough to hear.
Person 5	Male	73	1.55	The size of the stick is too long to hold.
Person 6	Male	75	1.72	Vibrating motor does not function well. It stutters like the battery runs out.
Person 7	Male	64	1.55	Above sensor cannot detect waist level obstacle at specific distance. Need to near the obstacle then it functions normally.
Person 8	Male	76	1.6	The stick functioning well. Unfortunately, sometimes buzzer and vibrating sensor triggered late after the sensor faced the obstacle at 15 second delay.
Person 9	Male	82	1.58	The placement for sensor 1 is too high for its to detect obstacles or people walk in front of the stick.
Person 10	Male	89	1.65	Cannot feels the vibrates from vibrating motors and the buzzer sound is too low.
Person 11	Male	78	1.70	The sensor cannot detect uneven floor and drainage
Person 12	Male	61	1.58	Sometimes the vibrating motor turned on even there are no obstacle detected

3.2.3 Obstacle detection with various setting

Table 3 shows the different locations for detecting different types of obstacles to show if the sensor can detect the object within the specific range.

Table 3: Observation of trial of ultrasonic sensor based on difference obstacle and location.

Type of obstacles		Trial (10 times)										Percent of success
House area (Indoors)	Chair	✓	×	✓	×	✓	✓	×	×	✓	✓	60 %
	Desk	×	✓	✓	✓	×	✓	✓	✓	×	✓	70 %
	Wardrobe	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	90 %
	Wall	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	100 %
	Dust bin	✓	×	✓	✓	×	×	✓	✓	✓	×	60 %
Pedestrians walk and field	Ramp	×	✓	×	✓	×	✓	✓	×	✓	✓	60 %
	Sewage/drainage	×	×	×	×	×	×	×	×	×	×	0 %
	Stairs	✓	✓	✓	×	✓	✓	✓	×	✓	✓	80 %
Parking lot	Car	✓	✓	×	✓	✓	✓	×	✓	✓	✓	80 %
	Lamp pole	×	✓	×	✓	✓	✓	×	✓	✓	×	60 %

4. Conclusion

Since there is currently no program in place to help blind people feel safe when they venture outside without a guide, the Smart Stick with GPS Navigation and Sensor Detection was created. For most blind persons, a walking stick is essential to getting things done every day. A distance measurement ultrasonic sensor and vibration alert vibration motors are used in this project. It was deliberate to define the measuring range for distance at 0 to 50 cm for ultrasonic sensor on low level between ankle while 80 cm for sensor at the waist level. When an object is within this range, the stick will detect it and create a vibrating signal to warn the user. The guardian only needs to observe from their cell phones to pinpoint the whereabouts of blind persons with the use of NodeMCU ESP8266 Wi-Fi and GPS module for location.

Acknowledgement

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