WEBSITE-BASED INDOOR NAVIGATION SYSTEM GUIDES FOR VISUALLY IMPAIRED COMMUNITY

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ABSTRACT

The project is about developing website indoor navigation for Kulliyyah of Engineering at the International Islamic University Malaysia, Gombak campus. The project is to provide support to the visually impaired community by guiding them to their destination inside the building. A assistive travelling device is developed to aid this navigation, as the current GPS and Wi-Fi based methods are not accurate enough for an indoor mapping because signals inside the building do not give accurate results when using Wi-Fi as a means to provide positional information. In this project, the KOE indoor maps are updated via a specially developed website that will guide the visitors by giving them instructions from point to point. The white cane with accelerometer is used to assist the visually impaired people to follow the instruction that was given by the web site. Sensors are also implemented to detect the floor level, assisting in navigation within the building. The results shows a high accuracy in navigation throughout indoor mapping.

***Keywords**: accelerometer, web development, indoor mapping, indoor navigation*

1.0 INTRODUCTION

Experts use the phrase "visual impairment" to refer to any degree of vision loss, including total blindness and partial vision loss. While some people are totally blind, many others suffer from what is known as legal blindness. Although they still have some sight, it has been diminished to the point that they would need to be 20 feet away from an object in order to see it as clearly as someone with perfect eyesight could from 200 feet away. Numerous tools are readily available around the nation to help the blind and visually impaired navigate the world. There are programs and services available to offer those who are impacted by vision loss in the areas of education, careers, health, legal, adaptive, and support. White canes are the most typical navigational tool for those who are blind. While this provides a fantastic solution for an obstruction that is close to the ground, obstructions that are higher than knee level or lower than the ground go undiscovered. Blind persons may experience difficulties as a result of challenging conditions such as crowd disasters, potholes on the road, and hanging tree branches [1].

The Global Positioning System (GPS) is for outdoor places for tracking and navigation. It does not include the coverage of indoor buildings because it is not accurate. Additionally, it uses GPS signals to navigate the indoor mapping for 1D. Pedestrian Localization System uses a smart phone to leverage the camera and Wi-Fi for tracking the radio map. It does not need user specification which makes it a challenge for the system to estimate the initial locations and other knowledge. The systems will use the fingerprint of Wi-Fi signals. Besides, it senses when it is a new location then the value of the signals will be filtered to know the locations [2].

Augmented reality is another solution which uses the real time view of the building by augmented reality. It is using it to assess the surroundings to be more accurate. By connecting the device to Wi-Fi location or Bluetooth beacons will help to the device location more accurately due to the GPS signal is hard to reach inside the building. The SLAM algorithms will assess the direction augmented reality for spatial precision. The user will scan a QR code to have access to a map of a specific building and continue with the camera to get the environment real time view. The system will have voice assistance to help the people who are visual impaired. This solution does not have to use a lot of sensors and has good accuracy. To have good accuracy, the system will be more expensive which will be very difficult to be used by everyone and every building as shown in Figure 1 [3].

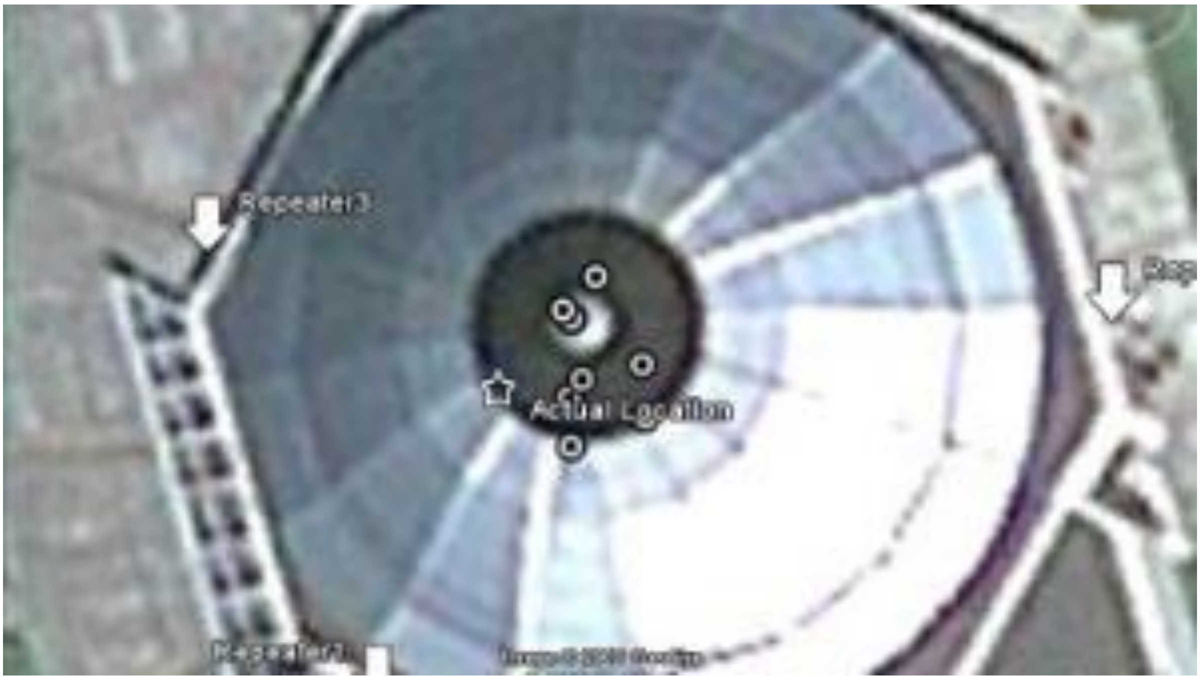

Figure 1: 2D indoor positioning experiment [3]

The internet of things is one of the revaluations that improved human life. A hardware component was developed to connect to IoT with android application to integrate a device that make their life easier. The component on stick is to detect the surrounding by using ultra sonic sensors. But this system does not help to guide and navigate for travellers and indoor mapping [5]. Smart vision was used for visual impaired community to help them by assistive device that using online computer vision service. This method uses machine vision and deep learning to build software that can unitize the online image processing service. It does not good as the normal eyes of human, but it can help them. This prototype does not reach all layers of society, therefore in future smart vision with be accessed to all the layers of human and will not be that expensive. It also will have more service that make the daily life easier for people with disabilities as shown in Figure 2 [4].

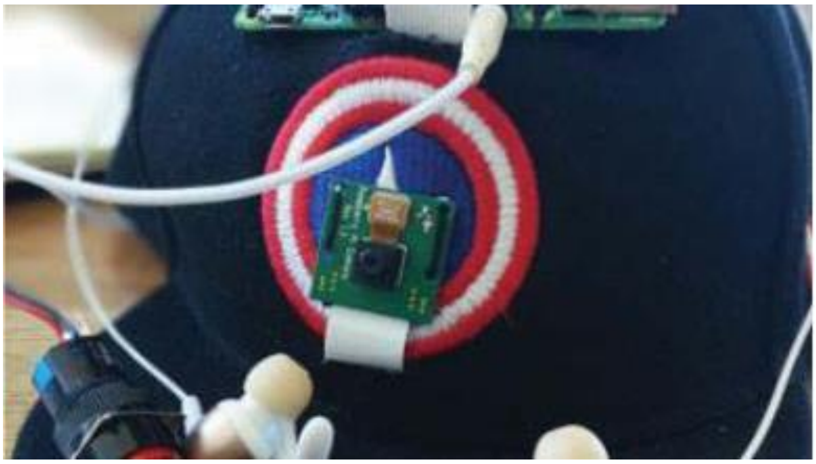

Figure 2: Smart Vision Prototype [4]

To sum up the previous points, tools like white canes help with navigation, but they struggle to spot obstacles above ground level. New tech, like outdoor GPS and smartphone-based systems, show promise in helping out, but they're not great at navigating indoors and can be pricey. The Internet of Things brings sensors that detect surroundings, but they don't guide travelers. Smart vision, using online computer tools, helps the visually impaired, but it's not accessible or cheap for everyone yet. These ideas need to become more affordable and available to really make a big difference.

2.0 METHODOLOGY

Visually impaired people usually used white cans with google maps application for navigation. While this gives an excellent solution for a near ground obstacle and outdoor places, it is not applicable for indoor navigation. Based on that, it is not helping them to explore the area around them clearly. They might get into an accident with crowded places or walls in the building. They will not know the way to their destination and which direction should follow.

This system consists of three parts, which are the website that support VIC, hardware's

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coding and navigation, and hardware components. This chapter will clarify the strategies that will be used in this project. It will discuss the techniques and software tools as well as what will be used to design the system. The software will consist of the following parts that have been mentioned earlier. It will use React Java Script for building the website that will assist the VIC. Besides, Arduino IDE software will be used to run the hardware's' components.

For this project, it will use React java script libraries to develop the website. Furthermore, the code will be written by using visual studio software by Microsoft. Then, by using React java script, the website theme and elements will be implemented. This is to ensure the website has smooth and easy browsing for its visitors. Then, vercel tools are used to publish the written java script code to the internet for anyone with the URL link to have access to the website.

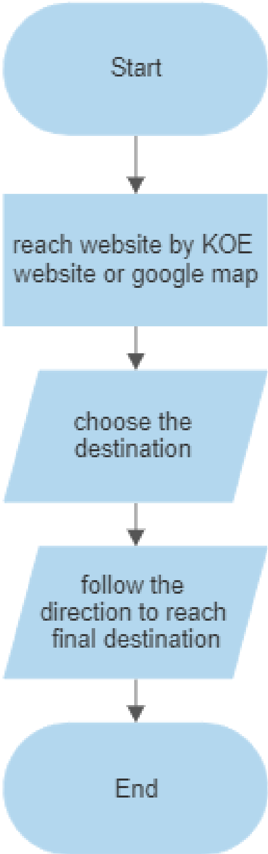

Figure 3: Website Development Flow chart

The system has two options to be able to access the website. The first one is by opening the website from google map or KOE official website. The second option is to use the QR code placed around KOE buildings for the visitors to open the website. The visitors will select their destination from the website and follow the instructions given to them to finally be able to reach their destination. In addition, the website provides multiple features for example, visitors can view the inside structures of the KOE buildings floor by floor which gives an overview look for them to have a better understanding of their surroundings.

For the impaired vision community, the website has the ability to navigate them through voiceover or audio instructions. Whereas Apple iOS consumers can use the voice assistance throughout the built-in iPhone accessibility function and in Android systems can use the acapella app provided in Google playstore.

The proposed system hardware consists of a helping white cane which is a device normally used by the visually impaired people with the implementation of an accelerometer sensor to help the vision impaired community reach their desired destination safely and precisely. The accelerometer will be programmed using an Arduino nano for the purpose of its small size and light. The accelerometer functionality is to measure the distance and send feedback for a motor vibration to notify the impaired person every 1 meter. Figure 4 shows the flowchart of the hardware development of the system.

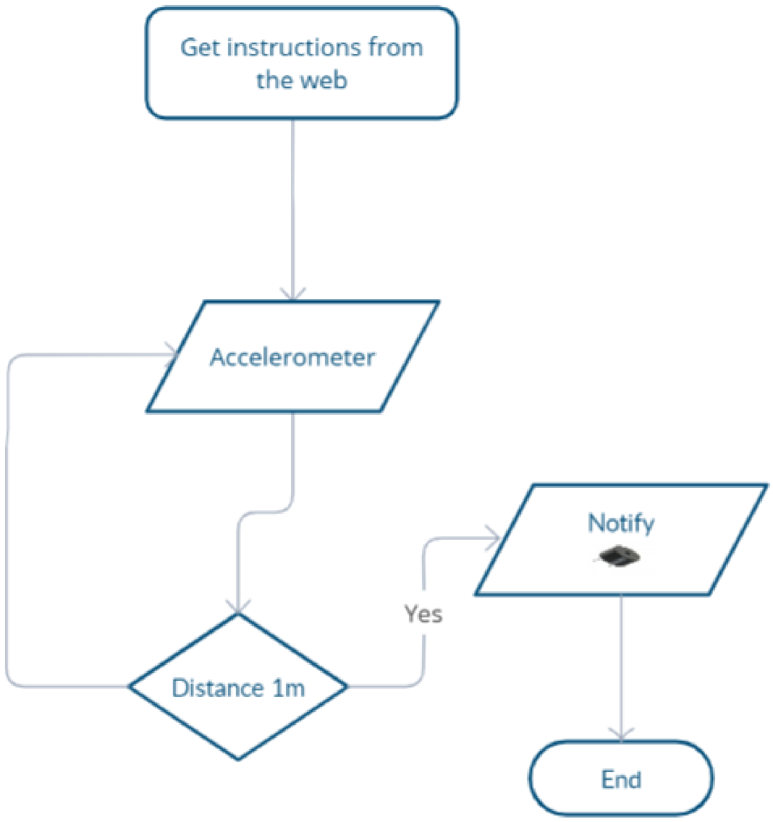

Figure 4: Hardware Development Flow chart

3.0 RESULTS AND DISCUSSION

In this section, it is all about exploring how hardware and software work together. It talks about how they influenced the results we found.

3.1 Simulation and Experimental Setup

In order to reach the objectives of this project the system works as follows. A website was created for the vision impaired visitors of the Kulliyyah of Engineering. This website instructs the impaired visitors through audio instructions, while the innovated-advanced white cane system assists them to avoid obstacles. There are multiple simulations done using solid-work software as well as the completed prototype will be discussed in this section.

A. Simulation Setup

1) SolidWorks

The design has been done using SolidWorks software. It contains two main parts which are main box and sensor box as shown in Figure 5.

Figure 5: Upgraded White Cane System

The sensor box as shown in Figure 6 contains two ultrasonic sensors that are used to detect obstacles. The first ultrasonic sensor with 45 degrees along the cane can detect obstacles with 23.63 cm height. The second ultrasonic sensor is placed 90 degrees along the cane and has the ability to detect above 23.63 cm. Once the sensor detects an obstacle a vibration motor will be turned on to warn the holder that there is an impediment. In addition, the box has a rechargeable unit.

These conditions mentioned above are only applicable if the holder of the cane is holding it at 45 degrees precisely. Therefore, the obtained heights may differ with different angles.

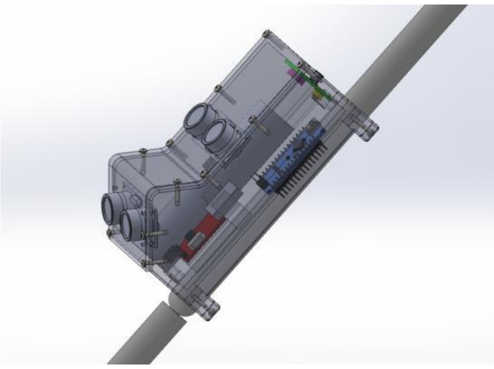

Figure 6: Sensor box

The indication ring which is used to indicate the direction of the sensor box. This small ring helps the impaired person to be able to know the exact direction of the box for it to be directed correctly as presented in Figure 7.

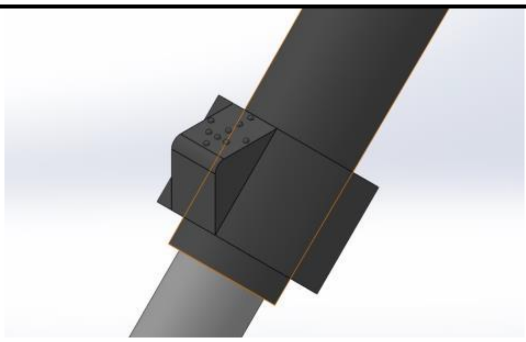

Figure 7: Indication Ring

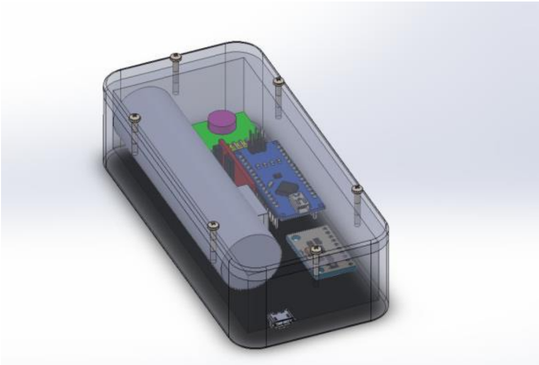

Figure 8: Main box

Figure 8 demonstrates the main box, not to mention it has a rechargeable battery and a vibration motor same as the sensor box. It has an extension for USB-microB to USB, for the charging purposes and a USB-A to USB-A to provide power to the components inside. Such as the vibration motor, microcontroller, and the accelerometer.

Similarly, the vibration motor implemented in the main box vibrates every 1 meter to give the knowledge to the person that he or she walked for 1 meter. This is aided by the

accelerometer sensor to sense the distance and calculate the steps that have been moved.

2) Website Design and Development

The website was created for the visitors of KOE. It contains the maps for normal people to look through and follow the instructions. As well, the visual impaired community will use the voice assistant to explore the website and follow the instructions to reach their destination.

The website interface is demonstrated step by step, on the main page of the navigation website. The website name is "Indoor Building Navigation Kulliyyah of Engineering" in International Islamic University Malaysia as showcased in Figure 9.

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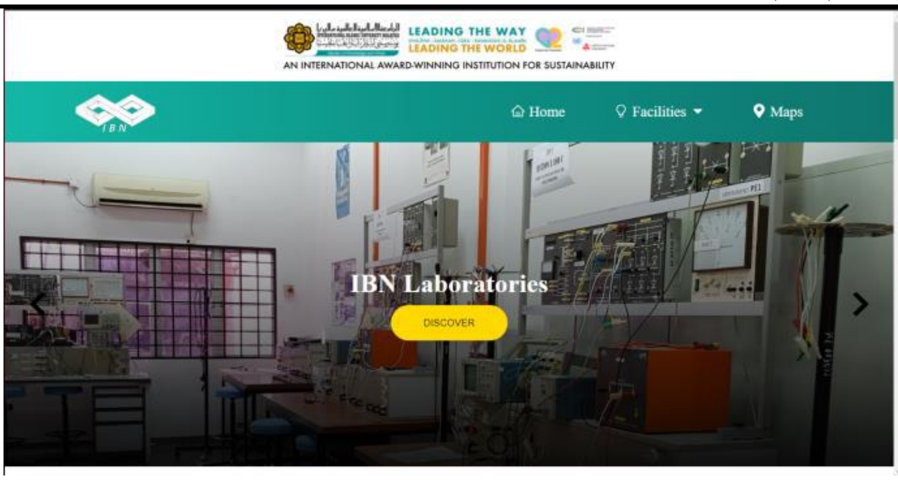

Figure 9: Website Main Page

The user-interface of the website as shown in Figure 10 consists of input controls, navigation components, information components, and containers. The home page is an information component which will redirect the user to the home page once is clicked. The facilities item is a container which contains a list of buildings in KOE. Whereas the maps item is similar to home page since it is an information component once the user clicks on it a pop-up window of KOE map will be shown to the user.

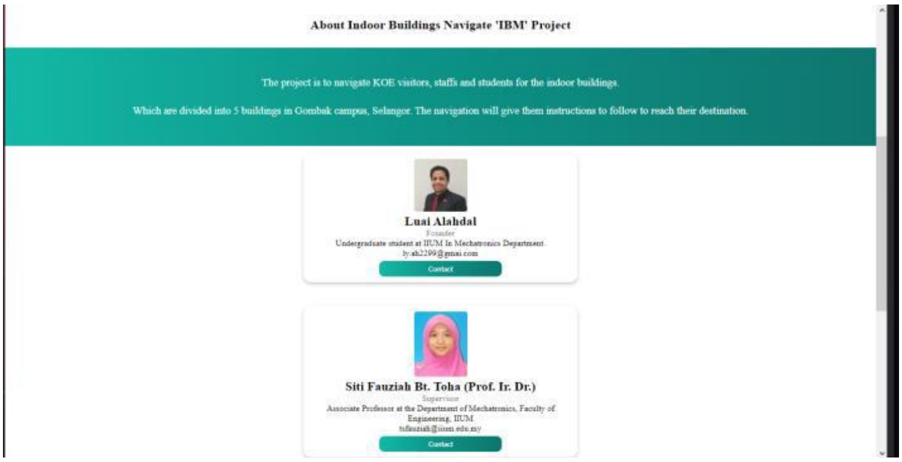

Figure 10: Website Interface.

The contact information of the founder as well as general knowledge about the website for easier browsing as shown in Figure 11.

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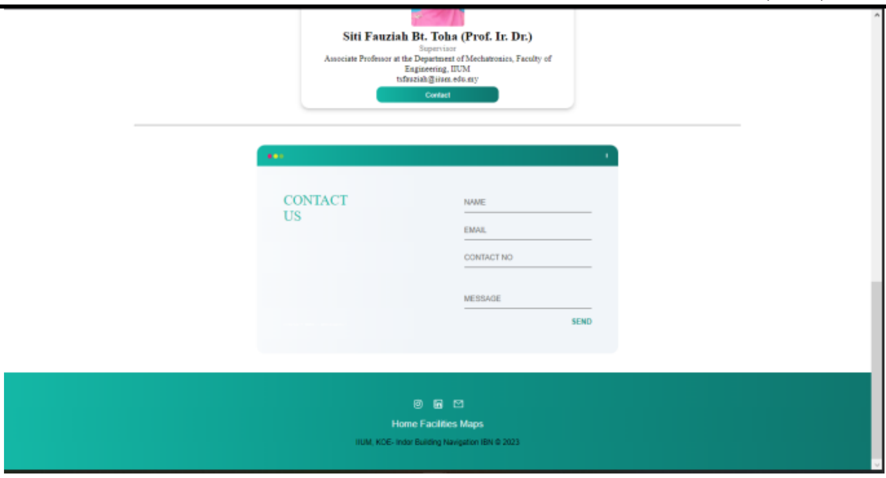

Figure 11: Contact Us Interface on the Website

The user can reach the technical team of the website for any information or complaints through filling in the boxes shown in the figure and click send therefore the message is sent to the official email of the website for further actions as presented in Figure 12. Once the facilities item is clicked the user will be redirected to this respective selected page as shown in Figure 13.

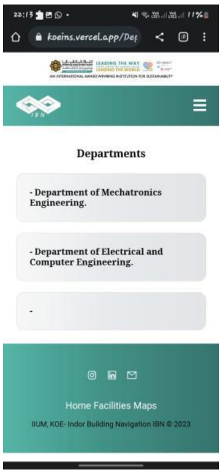

Figure 12: Departments' page by phone view **Figure 13:** Example of following direction

After that when the user is clicking the Departmental select button, the information related to the respective department, ie: Department of Mechatronics will pop-up to the user. By clicking the phrase "click Here!" the user will be directed to google maps KOE location as shown in Figure 14. Once the user clicks on any floor of E1 building the floor plan will be pop-up to the user as shown in the figure. By clicking the "Maps" item in the home page this page as shown in Figure 15 will appear to the user. Finally the KOEs floor plan as shown in Figure 16 is available to be viewed by the user.

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Figure 14: Map's page

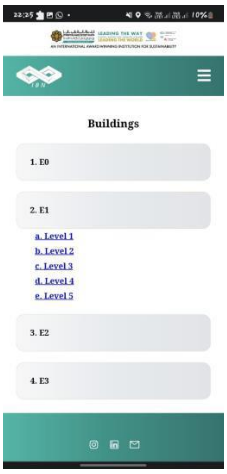

Figure 15: KOE E1 floors list

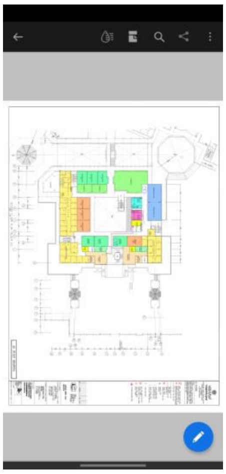

Figure 16: Floor's plan

B. Experimental Setup and System Testing

A prototype has been developed for the system. The prototype consist of an Arduino nano to control the sensors and vibration motor. The microcontroller is powered by a rechargeable battery. A serial adapter USB is used to activate the Arduino nano and the other components that converts the high voltage coming from the rechargeable battery to a 5V, for the system to function accordingly. Figure 17 shows the sensor box circuit prototype connections. The main box circuit connection is shown in Figure 18 where the circuit functions in a similar way as the sensor box. It only differs in that it has an accelerometer that calculates each step of the impaired vision person. The overall hardware prototype is showcased in Figure 19.

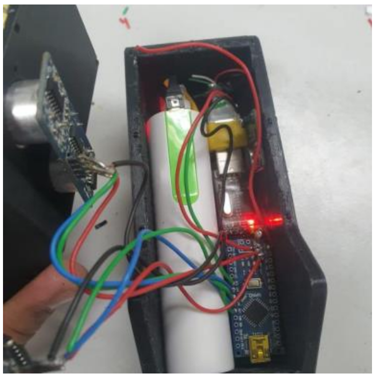

Figure 17: Sensor box prototype

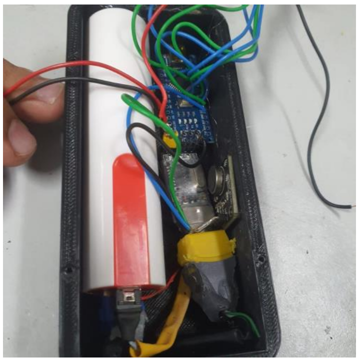

Figure 18: Main box prototype

Figure 19: Full prototype

Based on the prototype and simulation, the accelerometer sensor achieved satisfying results. It could calculate steps at approximately 85% accuracy by experimenting with the sensor for actual steps and then compare them to the steps that appear in the monitor. The hardware testing for the indoor mapping done in E1 Building is shown in Figure 20.

The same concept is replicated with different people and could be concluded that the average accuracy is within the similar range of 85%. It can also be said that the accelerometer sensor is reliable in obtaining the desired results with the surrounding environment. Meanwhile, the two ultrasonic sensors provided a much desirable result. These sensors were able to detect obstacles precisely as shown in Figure 21. In this case, a demonstrations of 23.63 cm height object detection is successfully tested.

The detection distance set for the sensors was less than 50 cm which is a safe distance for the visually impaired people to be warned before they face any obstacle ahead of them. Besides that, the vibration motor was functioning correctly as it vibrates once an obstacle is detected. Whereas for the main box prototype it vibrates each 1 meter. Demonstrations above 23.63 cm height with the 90 degrees ultrasonic angle as shown in Figure 22 is also achieved within the similar accuracy. The main box prototype was designed as desired as it was not heavy to carry and with a small size that can be put in a pocket, small bag, or to be carried.

Figure 20: The indoor mapping done in E1 Building

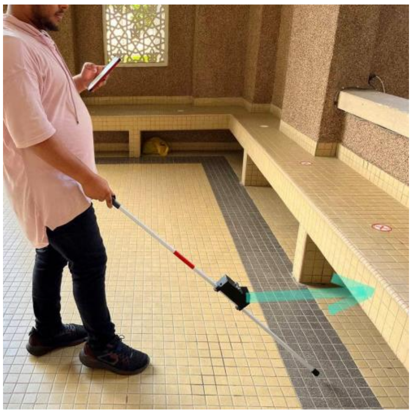

Figure 21: Demonstrations of 23.63 cm height object detection

Figure 22: Demonstrations above 23.63 cm height with the 90 degrees ultrasonic angle.

Moreover, all the design and specification objectives were achieved successfully combining both software and hardware. The designed website was able to navigate the VIC

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people throughout KOE buildings. With simple instructions and smooth interface, the tested sample could reach their destination safely. Furthermore, the implementation of the audio assistance to the website reached a remarkable result.

4.0 CONCLUSION

A review of the current and past studies was done on the indoor mapping and for visual impaired communities. The indoor mapping usually uses Wi-Fi to connect to the phone and navigate the user to guide it to the destination. Some of the studies used Bluetooth as well. The review of using a GPS signal for indoor mapping was described as the signal will not be accurate inside the building.

In addition, the Indoor Navigation System Guide for the Visual Impaired Community that utilizes a website can greatly improve the independence and mobility of individuals with visual impairments. This system utilizes a combination of technologies such as Bluetooth beacons, GPS, and audio guidance through the website, to provide users with real-time directions and information about their surroundings. It also allows for user customization and personalization of the navigation experience, making it more accessible and user-friendly. The website can be accessed by any device with internet access, including smartphones and tablets, making it widely available and easy to use. Implementing such a system in public buildings and spaces can greatly benefit the visual impaired community and promote inclusivity and accessibility.

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