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Design of Smart Walking Shoe for Visually Impaired People

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ABSTRACT

Technology helps disabled people to get things done easier and in the case of visually impaired people, technology surely enables them to communicate to the surrounding environment independently. The purpose of this study is to propose design of smart walking shoe for the visually impaired people that incorporated with multi sensors. The main purpose of the proposed smart walking shoe is to guide the visually impaired people in a smarter way rather than using traditional method of walking stick. The smart walking shoe is proposed to be integrated with components such as moisture sensor, ultrasonic sensors, button, DF Player and speaker and Agile method will be used in the development process that involves Brainstorm, Design, Development, Quality Assurance and Deployment phase. The pre-evaluation testing shows that the smart walking shoe is shown to be effective as guiding tool to the visually impaired people to navigate independently. The future studies will be conducted by development and tested in actual environments.

1. Introduction

World Health Organization (WHO)'s statistic in 2021 showed that at least 2.2. billion people all over the world having vision impairment or around 28.21% of the human population [1]. These visually impaired people are unable to navigate directions on their own and depend on guide dog or walking stick and people around them to move. As such, studies comprising of tools to help these people has been around and been carried out by incorporating smart devices and technologies to overcome their disability and move independently as normal people.

Visually impaired people are often known as blind as they are having difficulties to interact and feel the environment as well as the people around them. As their contacts with their surroundings are minimal, physical movement has become a biggest challenge for them. Commonly, visually impaired people are unable to move from one place to another place and difficult to identify the obstacles around them [2, 3]. Family and friends become their closest dependable people to support their movement in daily life. This leads to limited movement among the blind people as they need someone to guide them for their mobility and other routines .

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As technology has been one of the pivotal parts in daily life, over the last decades researcher have been trying to provide innovative and technology friendly way in assisting blind users to navigate independently. Options such as guide dogs, global positioning system have been growing tremendously to enable these special users independent. (Vikram Singh Parmar). Research also been conducted for designing a suitable system for the visually impaired people in detecting obstacles and dangers around them [2][4].

Smart walking stick is commonly designed to detect obstacles and help the visually impaired people to navigate freely and independently [3]. However, some obstacles such as water or even altitude are not widely provided and the visually impaired are prone to these types of obstacles as well as they might need to climb or goes down on stairs to reach certain designated place. As such, this research aims in identifying such obstacles and design a smart walking shoe that enable the visually impaired to navigate at any kind of situation independently.

In this paper, smart walking shoe was conceptualized to enable navigation or obstacle identifying for the visually impaired people. The design of smart walking shoe for the visually impaired people contains multi sensors such as ultrasonic sensor and water sensor, added with notification during an emergency fall which integrate the concept of Internet of Things (IoT) where electronic components were connected to detect these obstacles and guide the visually impaired people's navigation.

The next section will discuss on the related studies on smart tool for the visually impaired people and section three will continue on the methodology and followed by the conceptual design of the smart walking shoe and finally results on pre evaluation testing and followed by conclusion with future works.

2. Literature Review

Currently, many assistive technologies were designed in the attempt to enable disabled people to be more independent such as the visually impaired people since mostly depends on people or device for navigation in their daily life. Smart sticks is one of the most known design and invention that incorporated Internet of Things (IoT) which act as pervasive global computer network where anything and anywhere to be connected though Internet [2]. The IoT device are becoming more popular these days as it enables something to de done automatically without the need of human to operate and these eases the work of many that has be automated and easy.

IoT's key technologies include RFID, intelligent embedded systems, nanotechnology, and sensor technology. Finally, a product for the Internet of Things is created using a mix of all these technologies. RFID is crucial to the Internet of Things' ability to identify connected things. To fit into RFID tags or smart labels, all the data is encoded. RFID enables radio waves to be used by an RFID reader to read data from a label. Fast wireless data transmission between devices at short distances is made possible by near field communication (NFC) [5]. For straightforward data exchanges, Bluetooth Low Energy (BLE) has reduced battery consumption and latency. In order to support real-time decision-making, IoT applications require significant amounts of data storage. Fast-speed broadband networks are used by cloud computing to transport data, audio, and video [6].

IoT has been used in a variety of industries, including manufacturing and medicine. For instance, the ADAMM Asthma Monitor is a wearable gadget that patients can use to track and monitor their asthma symptoms. Users of IoT-based smart homes can remotely monitor and manage their home's electrical appliances in real time. The PIR sensor used by the anti-theft security system sends a signal to the microcontroller board whenever movement is detected [7].

Research was continuously proposing new and innovative way in improving the disabled people life. Various research has been providing efficient navigation aid for visually impaired people where

smart stick is one of the most known tools to aid these visually impaired people. Traditional method such as cane or guide dog has been the most used tool however some limitation such as inability to identify obstacles accurately and only through touch are one of the main reasons these were not widely considered and moved into new innovative tools such as smart sticks [8].

The visually handicapped use the classic white cane to let them move independently until the smart stick for the blind was developed[9]. The conventional walking staff, on the other hand, can only aid them in identifying the difficulties in front of them. There are many different types of smart sticks for the visually impaired being manufactured nowadays because to the rapid advancement of technology.

Author Nowhsin and his colleagues created an intelligent walking stick for those with vision impairments using Bluetooth, an Arduino Nano, a GPS system, and a mobile application. Any impediment that an ultrasonic sensor identifies will automatically be recorded through Bluetooth and informed to the user via a voice message delivered through a mobile app. In an emergency, it can send the user's location and alert them of their own location via sound. Using a GPS-based emergency SMS system function, visually challenged people can let their family members know where they are when they become lost [10].

In addition, Ramesh Satpute and his team created a smart cane using an Arduino platform and a GSM-GPS module. The smart stick uses GSM to call the user's doctor, phone the user's relative, and send an alert message and position to the user's relative. Using GSM-GPS, it will notify the user's loved ones and physician of their whereabouts and send an alert message in the event of a fall. The user will be informed through speaker of all alarm voice messages when there is an obstacle or stair in front of them [11]. As a result, it has been an excellent tool for the blind, especially in times of need. Many programmes or "smart sticks" have been focusing on exploiting Internet connectivity for providing notifications as technology has advanced.

A stick prototype known as a Radio Frequency Identification Walking Stick was created by Saaid [8]. Calculating the distance between a blind person and the sidewalk border enables them to walk on the sidewalk and prevents them from sliding off. The main elements of RFID technology are a radio frequency identification (RFID) tag, RFID reader, middleware, and a database. The RFID tags are positioned in this system at a specific distance from one another in the middle of the walkway. The system is reliable, as RFID technology provides an accurate level of detection, but for this, a lot of RFID tags need to be placed in many places, and each tag has a specific working range, and hence this requires a lot of testing. In addition, if any tag is covered by anything, then it may not work properly [12, 14].

Ultrasonic sensors, sometimes installed on eyeglasses, are used by other devices [13]. Single-strand copper wires that may not be very sturdy link the components to the central unit. Ultrasonic range finders fitted on eyeglasses by EyeMate are used to identify objects on the left and right as well as on the ground [14]. When GPS is available, it also uses it to track the user's location, but it doesn't use it for navigation or other network provider information. Another obstacle avoidance system uses five ultrasonic sensors, each of which is activated by a raspberry pi 2, to detect impediments [8, 15]. If the minimum recorded distance is less than a threshold value, there is a barrier present.

Some of these devices can also output sound or voice, however doing so runs the danger of obstructing outside sounds. This includes the use of speech on speakers to warn users about obstacles' locations and distances, as well as wet floors [16], a buzzer by one of the temples to warn them about head-level obstacles, and three tiny vibrating motors in the shoe collar to signal ground-level obstacles of various heights and holes [17]. Besides that, design of the smart shoe could ossibly

harvest energy to be sustainable and efficient especially in the use of wireless sensors [18]. Some users might find the buzzer's sound irritating.

The smart walking shoe proposed is portable device where it should be compact in size and lightweight that is easy to be work and used daily. The smart walking shoe also explores the alerting system to the user when come across on obstacle in front or even stairs and water. This shoes also employs notification system and a buzzer to alert the people surrounding in case of emergency faced by the visually impaired people such as sudden fall. The remaining sections will describe the design of the smart walking shoe that incorporated multi sensors followed by conclusion and future works on this study.

3. Methodology

The methodology used is Agile methodology which consists of five stages: brainstorm, design, development, quality assurance and deployment.

3.1 Brainstorm

The requirements are defined during the brainstorming process. The author conducted an evaluation survey form and sent it to the chosen organisations for the blind, such as the Society of the Blind in Malaysia and the Malaysia Association for the Blind, to gather the needs of the target population (MAB). According to feedback, 93.1% of respondents believed that the application of the smart stick concept to shoes will benefit those who are blind or visually impaired. This demonstrates that most people believe that shoe-based smart innovation will simplify their navigation because smart sticks may not always respond exactly how they want them to and run the danger of getting lost when used outside.

3.2 Design

The design phase is crucial for addressing any requirements or issues that the concept shoe must address. The smart walking shoe's major objective is to ensure the safety of visually impaired persons by adding water detection, obstacle detection, and notification for emergency purposes. This design includes multiple sensors, including moisture and ultrasonic sensors, which are covered in more detail in the following section.

3.3 Development

The task starts during the development phase when the team establishes the requirements [3]. Ultrasonic sensor, moisture sensor, DF player, and Arduino Uno board are among the prepared components. To accomplish all of the goals, the developer started by connecting all the parts and compiling code in the Arduino IDE.

3.4 Quality Assurance

In the quality assurance phase, the project's performance is evaluated, and bugs are fixed [3]. All of the components have been checked at this step to make sure they are appropriate for the project and capable of responding appropriately. The best solution was used to address every issue that arose during testing. Additionally, the project's performance has continually improved.

3.5 Deployment

The project needed final confirmation before it could be used during the deployment phase. A shoe prototype was made by a developer and tested. The shoe prototype is put through rigorous testing by the designer, who then makes improvements.

4. Concept Design

The main goal of our study is to assist visually impaired people to navigate easily without worrying about the obstacles or emergency. It uses an ultrasonic sensor to detect obstructions within a configurable range of up to 2 meters, combined with moisture sensor to sense any water obstacles such as flood or others to avoid slippery road during navigation as shown in the Figure 1 below.

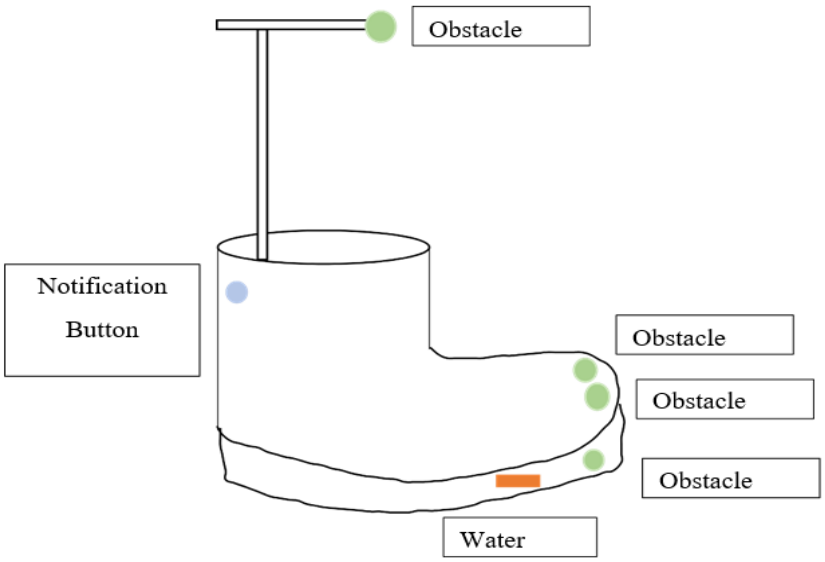


Fig. 1. Smart Walking Shoe Design

Besides that, the concept smart walking shoe also uses ultrasonic sensor to detect the stairs identifying if the user should move upwards or downwards according to the given instruction through the speaker provided. Besides that, the shoe also enables to send notification through mobile application in case of fall or emergency by pressing a button given on the shoe.

The smart walking shoe will be completed by connecting all the wiring with the electrical components that includes ultrasonic sensor, moisture sensor, DF player, speaker, WiFi module. The platform used within the smart walking shoe is Blynk whereas this application is easy downloadable in smart phone and connected to the smart device through Bluetooth.

The hardware for the smart walking shoes consists of Arduino Uno, ultrasonic sensors, moisture sensors, button, ESP8266 WiFi Receiver and speaker. The table below shows the function of each of hardware used and the figure below shows the hardware used.

Table 1
The hardware used on Smart Walking Shoe

Electronic components	Function
Arduino Uno	To execute the code on Arduino IDE and interact with sensors' input and output
Ultrasonic sensors	To detect obstacles
Moisture sensor	To detect water on the floor
Emergency button	To ask for help from their family member via Blynk
ESP 8266 WiFi Serial Transceiver Module	To connect WiFi to make sure the family member can receive notification via Blynk when the user touched the emergency button
Speaker	To notify the user

Integrated Development Environment for Arduino is the programme used to upload the code (IDE). Through a USB cable, the code is written and uploaded to the Arduino IDE. This project contains numerous libraries, including NewPing.h, ESP8266 Lib.h, and Blynk.h.Blynk is an Internet of Things platform that enables smart walking shoes to deliver notifications to smartphones. Esp 8266 WiFi Receiver will enable communication between the Arduino UNO board and Blynk application in this project. As a result, the selected close relative will be notified when the visually impaired person presses the button on the smart shoe and can then request assistance through this app.

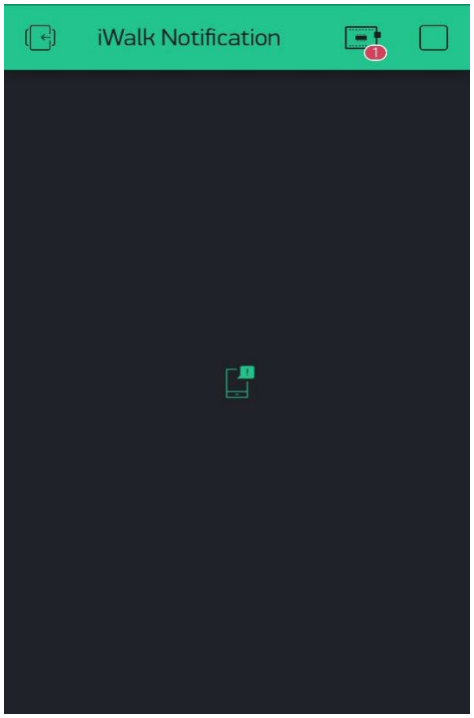


Fig. 2. Interface of App

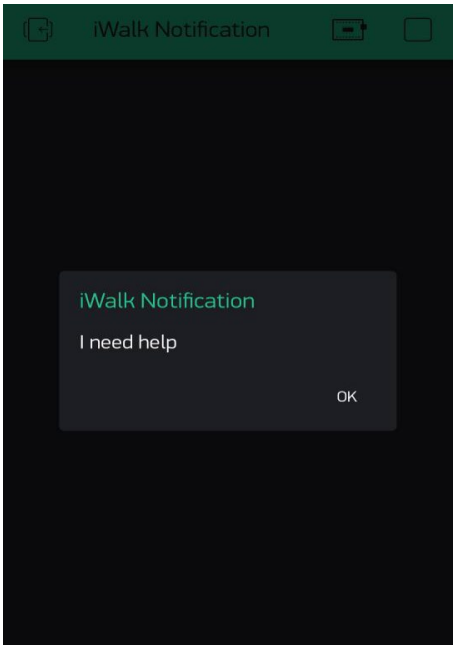


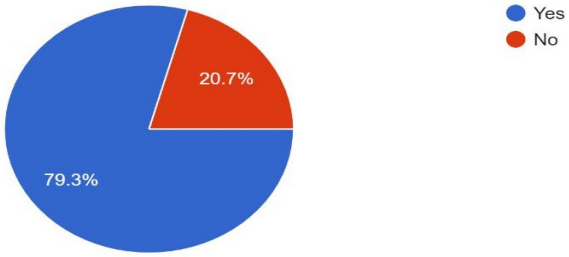
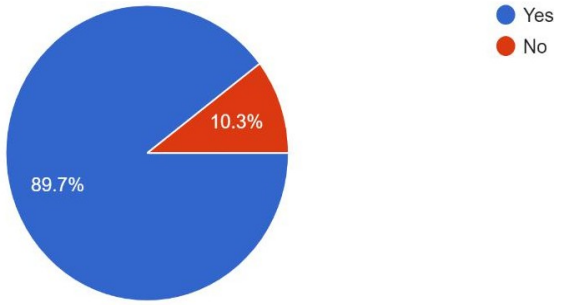
Fig. 3. Notification asks for help

3. Results

3.1 Pre-Evaluation Test

To gather additional feedback, a survey form and a demonstration film of the smart walking shoe prototype's operation were given to the general public and the targeted groups. The analysis based on the questions answered is presented in Table 2 below.

Table 2
Pre Evaluation Results

Chart or question	**Analysis**
 **Have you ever heard about an assistive technology that help visually impaired people?**	78.3% of those surveyed said they had heard of assistive technology that could be useful for those who are blind or visually impaired. However, 20.7% of the respondents claimed never to have heard of such things. They mainly used traditional sticks for the assistance technologies they were familiar with.
 **Do you think the "smart shoes" is more effective and convenient than smart stick and traditional cane?**	According to 89.7% of the survey participants, "smart shoes" are more practical and useful than smart sticks and conventional canes. However, 10.3% of people did not concur with that because: 1. Stick has a detection range control. 2. Smart shoes may be heavy and require batteries. 3. The user could need some time to adapt smart shoes to his life because he must learn to walk independently

According to the results of the pre-evaluation testing, the shoe did succeed in achieving the project's goal of assisting in navigation. In addition to protecting the user from a fall or injury, several components were used to support various navigations.

One of the best features is the sound function, which alerts the user to situations like a frontal impediment, an upstairs or downstairs location, and water on the floor. Though there is still potential for growth, a real-world concept shoe may use more wireless components to make it more aesthetically pleasing and comfortable to wear.

4. Conclusions

This paper presented smart walking shoe for the visually impaired people concept design as it consists of multi sensors that enable for obstacle detection system. The pre-evaluation results shows that the smart walking shoe enable to identify the needful obstacles for the visually impaired people and help them to navigate independently. With more research, users who have recently been blind will be able to think more deeply about the same. We draw the conclusion from this study that blind and low vision people may benefit from wearing smart walking shoes to improve their navigations in daily life. In the future, longitudinal research will be necessary to determine whether the smart walking shoe will be able to supplement their current mobility, making them independent with repeated use. The following evaluation studies will be carried out in actual moving settings. There are also a lot of improvements to be taken onto the project to make the smart walking shoe more efficient and useful in the future.

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