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THE UTILIZATION OF PHOTODIODE IN MAKING AN ENHANCED OCULUS CANE FOR VISUALLY IMPAIRED PEOPLE

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ABSTRACT

Vision impairment is a worldwide problem which significantly impacts quality of life of all ages. For this reason, this study aims to create an enhanced oculus cane which uses a photodiode to help the visually impaired people detect objects, and mobilize freely and safely. To assess its effectiveness, a PN photodiode was utilized which detects objects with programmed barcodes in various distances and sizes. Response time in identifying objects was tested together with the loudness of audio volume measured in decibel. The cane is used mainly in the household, wherein barcodes are scanned by a photodiode connected to a Bluetooth module and transmitter. The Bluetooth module and transmitter are linked to a digital amplifier audio board and double diaphragm speaker, which are used to verbally transmit the name of the object with barcode. The results proved the capabilities of the Oculus cane with 1.60 seconds response time, and scanning range in distances of 4 cm. (minimum) and 22 cm. (maximum), and the sizes of the barcodes 3 cm. and 5 cm. The loudness of the audio volume from the speaker of the Oculus cane was 82.7 dB, the safe level which will not cause damage to the ears. It is therefore recommended to use the enhanced oculus cane with photodiode as an alternative to existing smart canes which is more affordable and offers features which will greatly help visually impaired people live an independent and safe life.

KEYWORDS: Bluetooth, Indoors, Photodiode, Smart Cane, Visually Impaired

1. INTRODUCTION

People who are visually impaired have a higher risk of experiencing any kind of unintentional injury. There are 285 million estimated visually impaired people worldwide, according to the World Health Organization (WHO). It can be extremely difficult for visually impaired people to navigate alone, which

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puts their physical safety at risk and causes frustration, low confidence, and diminished autonomy (Jafri, 2018). Those with vision impairment who travel alone are more likely to use a white cane as a mobility aid (Attia & Asamoah, 2020). Yet, there are significant problems with utilizing a white cane because it needs to be close to the obstacle and can sense the location of the obstacle with its tip. While sensing obstacles by the white can they could get hit by other obstacles around them. White cane gives no knowledge of the obstacle nearby. (International Journal of Engineering Research & Technology, 2020).

Several technology-assisted aids are available to help blind and visually impaired people perform their daily activities. Sensor canes are unified ultrasonic sensors which notify visually impaired users of varying obstacles while empowering independence in mobility. According to Slade & Kochenderfer (2021), sensor canes can be heavy and expensive weighing up to 50 pounds and costing $6,000. Currently, the available sensor canes are technologically limited as it only detects objects right in front of the user (Myers,2021). While this is better priced compared to other similar assistive technologies, it is nowhere near affordable for those who are poor or unemployed, especially with the low rate of employment of blind people, with only 44% of blind people in America employed (American Foundation for the Blind, 2017).

In the study, the enhanced Oculus Cane is made from environment-friendly and cheap materials which can perform like those existing smart canes equipped with additional features installed to help visually impaired people navigate freely and safely. It used recycled PVC pipe as a stick and inside it are the materials assembled working on detection, identification, and transcribing possible obstacles the users may encounter. Meeting the criteria, the enhanced oculus cane is limited to household indoor use with the familiarization and empowerment of visually impaired people from its surroundings, especially those living alone or with less to minimal supervision of their loved ones. To test its effectiveness, the researchers used programmed barcodes attached to various objects which the enhanced oculus cane must identify in terms of its distance in centimeters, the size of the barcodes used, the response time or operational time, and its ability to give a signal through the voice-operated system on its loudness in audio volume, and last but not the least on what specific obstacle or object is being detected by the product.

The Oculus Cane will be using a class B Bluetooth module to ensure performance at various distances. According to Laird Connectivity (2022), a class B Bluetooth module, also known as class 2 has an operating range of 10 meters. It has a maximum power of 2.5 mW (4 dBm). As shown in a study by (Yuan et al., 2020) this Bluetooth module class is the most compatible because the operating range of the Bluetooth module will be able to cover a whole house. Class 2 Bluetooth module is the same Bluetooth module used in most mobile devices.

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The main component of the enhanced Oculus is the PN photodiode, for it scans the area for bar codes. As explained by Agarwal (2016), a photodiode is a PN-junction diode that uses light energy to generate an electric current. It is a particular kind of light detector that converts light into current or voltage depending on the device's mode of operation. It includes surface areas, optical filters, and built-in optics. When the photodiode's surface area grows, the reaction time of these diodes slows down. These are specifically made to function under reverse bias circumstances, which calls for connecting the photodiode's P-side to the battery's negative terminal and its n-side to its positive terminal.

With the making of the enhanced Oculus cane, visually impaired people can be empowered and live independently and freely. The ease and familiarization of objects around them especially at home will prevent future accidents and unintentional injuries. This also offers an alternative to expensive smart canes having additional features and functionalities which can detect objects, identify a range of distances in various centimeters, and alerts the user to what specific obstruction they may encounter beyond compare adding its low cost and affordable price, thus safety and effectiveness is never compromised.

RESEARCH QUESTIONS

The main objective of this study was to create an enhanced Oculus Cane for visually impaired people using a Photodiode. Specifically, the study sought answers the following questions:

1. How effective is the enhanced oculus cane using photodiode in scanning barcodes in objects in terms of:
   1.1. distance in centimeters; and
   1.2. size of barcode?

2. How long is the detection time that the enhanced Oculus cane can read barcodes in objects?

3. What is the loudness of the audio volume that the Oculus cane can produce in terms of decibels?

Hypothesis

H1: It is feasible to utilize the Photodiode in making an enhanced Oculus Cane for visually impaired people.

II. METHODOLOGY

The study utilized the experimental design of research. Tanner (2018) mentioned that experimental research investigates the cause-and-effect relationships of the dependent and independent variables. In this study, the use of a Photodiode is the independent variable and the Enhanced Oculus cane is the dependent variable. The quantitative method of research was used in this study which provides techniques that enable the researcher to put a hypothesis to the test and conduct a methodical, scientific investigation of the causal relationships between the variables. It is necessary to use this method because it allows for better control over the variables and serves as an advantage in finding accurate results.

The following steps-by-steps procedures were presented on how to make an enhanced oculus cane for visually impaired people using a photodiode along with the testing procedures to prove its effectiveness.

Ensuring the protection and maintaining safety

Wear personal protective equipment such as safety goggles, safety gloves, safety shoes, and a laboratory coat while performing the procedures below to avoid hazardous conditions.

Connecting Bluetooth Audio Board- Receiver/Transmitter, and Digital Amplifier Audio Board to battery

1. Get the Bluetooth audio board receiver/transmitter and digital amplifier audio board.
2. Connect the positive and negative jumping wires from the audio board receiver/ transmitter to the 9-volt battery supply pads.
3. Check right away if there is electrical voltage using a multimeter.
4. Attach the digital amplifier audio board using the same jumping wire connected to the 9-volt battery.
5. Ensure that the audio board receiver/transmitter and digital amplifier audio board are linked properly to the 9-volt battery.

Linking Bluetooth Module

1. Connect the wires from the Bluetooth Audio Board to the enabled key of the Bluetooth Module.
2. Connect the wires from the receiver pad of the Bluetooth Audio Board to the TX key of the Bluetooth Module.
3. Connect the positive wires of the battery to the battery pads of the Bluetooth Audio Board Receiver/Transmitter and Bluetooth Module.
4. Check if the wiring is active using the multimeter.

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1. Attaching Double diaphragm speaker
2. Connect the wire from the transmitter pad of the Bluetooth Audio Board to the CP4 of the Digital Amplifier Audio Board.
3. Link the wire of the audio output of the Bluetooth Audio Board to the wires of the Double diaphragm speaker.
4. Connect the wires of the function pads transmitter of the Bluetooth Audio Board to the IRFP460 of the Digital Amplifier Audio Board

Connecting the Bluetooth Module and Transmitter to the Photodiode

1. Connect the RF Xformer pads to the photodiode wires.

An object with a barcode was placed at various distances in centimeters to test the effectiveness of the enhanced oculus cane using a photodiode, and with the help of a ruler, data was properly recorded, revealing the minimum and maximum range of an object in terms of distance in centimeters.

On one hand, barcode size is important for object recognition. In the study, researchers used two different sizes of barcodes for objects that were scanned by the oculus cane, and the size of the barcode in centimeters was determined using a ruler.

On the other hand, response time is crucial in the study to prompt the visually impaired people in identifying objects which might hinder mobilization and perhaps the occurrence of accidents. Using a timer, the researchers recorded how quickly the Oculus cane responded. Three trials were set to reveal the response time on the detection of barcodes that the oculus cane can scan.

Lastly, the researchers used a decibel meter next to the product while scanning the barcode sticker attached to a certain object to measure the audio volume's loudness regardless of proximity and the location of the speaker located inside the Oculus cane.

III. RESULTS

This section presents the results and interpretations of the data that were collected during the testing procedure in relation to the research questions.

1. Effectiveness of the enhanced Oculus cane using photodiode in detecting barcode in terms of:

1.1. distance in centimeters

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Table 1 1.1. Accuracy of Photodiode in Oculus cane measuring distance in centimeter

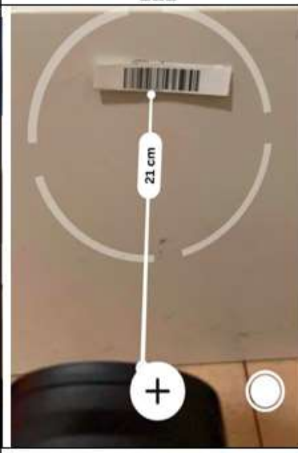
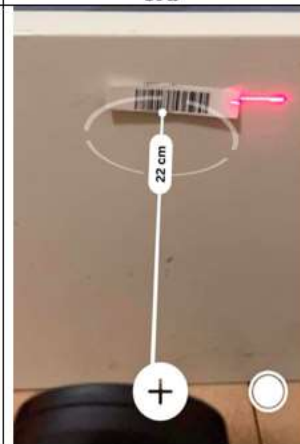
Trial	1st	2nd	3rd
Photos			
Distance in centimeters	4 cm (Minimum range)	21 cm	22 cm (Maximum range)

Table 1 presents the accuracy of the photodiode in detecting barcodes at various distances in centimeters. The researchers used a sample-programmed barcode sticker and measured the distance between the sticker and the photodiode to assess the accuracy of photodiode detection of the barcode in terms of distance in centimeters, revealing the minimum and maximum range of the photodiode scanner. In the first trial, the minimum range of the photodiode scanner was 4 cm, while in the second trial, the range was 21 cm, and lastly, in the last trial the maximum range of the scanner was 22 cm. According to Avalon (2018), A standard range barcode scanner can easily read barcodes that are a few feet away or that are as close as a few fractions of an inch. While a long-range scanner can read a barcode as far as 70 feet away.

1.2. The size of the bar code that the Oculus will scan in centimeters

Trial	Size	Image
1	3 cm	
2	5 cm	

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Two barcode stickers with various sizes in centimeters were used by the researchers to evaluate the sizes of the barcodes that the Oculus scanned. The initial test successfully scanned a barcode that measured 3 cm in length. A 5 cm-long barcode was used in the second test, which was also successfully scanned. In the first test, the barcode measured 3 cm and was converted to inches at 1.181 inches. In the second trial, the barcode measured 5 cm and was converted to inches at 1.986 inches, falling within the minimum (1.175") to normal size (1.469") of barcodes that can be read by photodiode scanners (Blue Label Packaging Company, n.d.)

Table 2 The response time of the Oculus cane in seconds

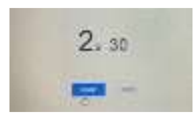
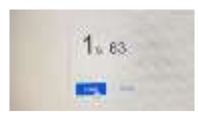
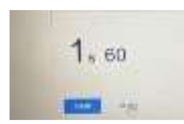
Trial	Seconds	image
1	2.30 seconds	
2	1.63 seconds	
3	1.60 seconds	

Table 2 shows the response time of the oculus cane in seconds. Using a timer, the researchers timed how quickly the Oculus cane responded. The product was put through three tests, with the process times for the first, second, and third trials being 2.30 seconds, 1.63 seconds, and 1.60 seconds, respectively. It can be said that the oculus cane reached its peak performance in the third trial when a response time of 1.60 seconds was measured. Response time also known as operational time is dependent on the photodiode used in the enhanced ocular cane which is determined by the capacitance of the P-N junction. It is the time needed for charge carriers to cross the P-N junction. This is directly affected by the width of the depletion region. According to Agarwal (2016), a PN-junction photodiode has a high response time since the capacitance of the junction is decreased, and so the speed of the photodiode increases.

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Table 3 The loudness of the audio volume of the Oculus cane in terms of decibels

Trial	1st	2nd	3rd
Photos			
Loudness in decibel	80.5 dB	80.8 dB	82.7 dB

Table 3 highlights the loudness of the audio volume the Oculus cane can detect which was measured in decibels using a decibel meter application. The researchers tested the loudness of the audio volume regardless of distance and location of the speaker placed inside of the Oculus cane by putting a decibel meter beside the product whilst scanning the barcode sticker placed in a specific object. Table 3 lists the various tests used to measure a product's volume in decibels. In the first measurement attempt, the product's audio volume was 80.5 dB, but in the second measurement attempt, it was 80.8 decibels. The audio loudness for the third measuring attempt was 82.7 dB. It took several trials to ascertain the average audio volume of the Oculus cane regardless of distance and location and to assess whether there were any noticeable fluctuations in the audio volume.

Every trial featured a little boost in decibel volume, with gaps of less than 1 decibel on average, except for the final trial, which had gaps of more than 1. When looking more closely at the outcome, it can be said that this slight shift in audio volume is common.

According to Byers (2021), the integrated loudness then moves the level of the entire piece of audio up or down until the desired integrated loudness is achieved. That means the entire file is gained up or down in one fell swoop. Additionally, the finding confirms that the Oculus cane is audible and secure for human ears.

IV. DISCUSSION

People who are blind or visually impaired can independently and securely navigate their surroundings with the help of white canes as explained by Ortiz (2021). A long white cane is used for mobility which most people who are blind or have low vision use. (Vision Australia, 2023). White canes do not guarantee the complete safety of their users due to their simple design to accommodate visually impaired people fully. At present, the existence of smart canes with the use of technology like vibration features to alert users whenever there is an obstruction on the way was notable for having a significantly higher price range than the average white cane which visually impaired people struggling with finances cannot afford to have. (Sawers, 2022).

The Enhanced Oculus cane gives a fair chance for visually impaired people to mobilize safely with its features in detecting objects in minimum and maximum distances in centimeters and recognizing obstructions easily through the audio feature to alert the user at a cheaper price. This study aimed to create an enhanced oculus cane out of a Photodiode scanner that is budget-friendly and cost-effective. This research sought to analyze the effectiveness of the enhanced oculus cane in terms of the range for the photodiode scanner, size and the response time of the barcode that the Photodiode will scan, and lastly, the loudness of the audio volume the product produced to alert its users was tested accordingly.

Based on the findings of the study, it is therefore concluded that the Oculus cane can detect objects at various distances with a minimum range of 4 centimeters, and a maximum range of 22 centimeters. Objects with barcodes were scanned successfully as the enhanced Oculus cane recognized barcode sizes from 3 to 5 centimeters which adhered to the minimum and normal standards of barcodes. Response time played a critical role in the detection of possible obstruction to the mobilization of visually impaired people as the output of the study detected objects for 1.60 seconds to 2.30 seconds respectively. Additionally, the enhanced Oculus cane was equipped with an audio alerting feature safe to the human ears measured at 80.5 decibels up to 82.7 decibels.

This study offered valuable insight to visually impaired people and their families into the use of the enhanced Oculus cane as an alternative to the available smart canes, showing that it is more affordable and may have additional characteristics that make it easier to move around and recognize objects easily.

Further, future researchers and programmers may also find useful mechanics by finding a more advanced diode to make the product more versatile and practically usable in external environments without the use of barcodes.

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