Design and Implementation of The Blind Navigation Aids Using Ultrasonic Sensor

by Eki 8

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***Abstract*— Visually impaired navigational aids in general still use manual tools to be less effective for blind people to navigate. Visual aids for visually impaired people using ultrasonic sensors are considered a solution to make it easier for blind people to navigate. This system is designed to work when detecting objects at a distance of 200 cm. The system produces output in sound and vibration, which will have a more excellent value when detecting objects at close range and have a small value when seeing things at a distance. The system modules are placed in several positions on the user's body to help determine the position and approximate length. This navigation aid uses ultrasonic sensors as object detectors with buzzer and vibrator as actuators and Arduino pro mini as system microcontroller. The result of this research is that the system can detect obstacle objects at a predetermined distance and find out the obstacle object's position to assist users in navigating.**

Keywords—blind, navigator, ultrasonic

I. Introduction

The sense of sight is one of the vital sources of information for humans. It is no exaggeration to say that most of the information obtained by humans comes from the sense of sight, while the rest comes from the other five senses. Thus, it can be understood that if someone has a disturbance in the sense of sight, then the ability of their activities will be minimal because the information obtained will be much reduced compared to those with normal vision [1].

Navigation aids are necessary for blind people to recognize their environment when they are going to carry out daily activities. Especially when blind people walk, by using a cane, blind people can recognize objects in the area they are going to pass. Information is obtained through the hands in vibrations from sticks that are touched/beaten to objects. However, blind people can only recognize objects if the stick is touched to an object with minimal information by using a stick. To solve this problem, needed a tool that can provide broader information and make it easier for blind people. One of them is by using an ultrasonic [2].

An ultrasonic sensor is a sensor that works on the principle of sound wave reflection and is used to detect the presence of a particular object in front of it. Ultrasonic sensors are commonly used to detect obstacles and provide information to users. In addition, ultrasonic sensors are also used to determine the distance of the obstacle object to the user [3].

The research aimed to design and implement and analyze the performance results of visually impaired aids using Arduino pro mini and ultrasonic sensors. The limitation of the problem is that the tool will only work on obstacle objects that can reflect ultrasonic signals. In addition, testing is carried out on flat terrain and high obstacles used in testing using average - average human height. As for some related research that has been done before by others, namely, renstra C. G.Tangdiongan research, Elia Kendek Allo, Herwin R. U.A.Sompie designed a tool that provides information in the form of estimation of the distance of an obstacle with the user in the form of sound and vibration information, ultrasonic sensor HC-SR04 is used as an obstacle detector, information in the form of sound used by catalaex mp3 player module, obstacle indicator in the form of vibration used cell motor vibrator [4].

The research entitled "Prototype of Assistive Device for the Blind in the Form of a Stick Using Arduino and Ultrasonic Sensor" which was studied by Charles Setiawan, discusses the design of a tool in the form of an automatic stick that can detect objects and provide information through a buzzer.

Many researchers have researched on the use of ultrasonic sensors as object detectors. However, in this research, the bracelet is used as the main design and uses the Arduino pro mini microcontroller, this is what distinguishes this study from previous research.

II. Research Methodology

In the study using research methodology compiled using flowchart as below :

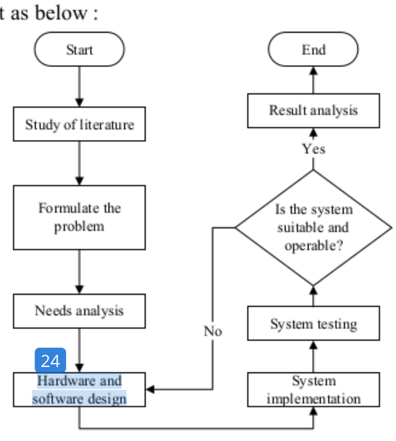

Fig. 1. Research flow

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III. Design And Implementation

A. Design

System design determines the weaving component of a tool to be created so that the result is as desired. After collecting some references and analyzing the need for tool creation, this system diagram block includes the Hardware and Software design shown in Figure 2

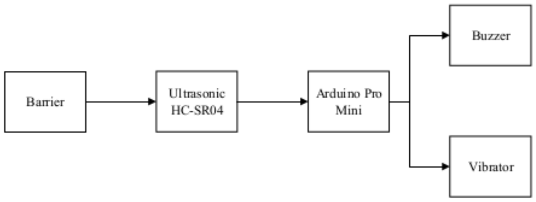

Fig. 2. Block Diagram

The diagram block in Figure 4.1 shows that the object is an obstacle that will be detected by the HC-SR04 ultrasonic sensor that will be processed by the Arduino Pro Mini microcontroller with actuator output in the form of a buzzer and vibrator when the system detects the system obstacle object will emit sound on the buzzer and shake on the vibrator [5]. The number of buzzer sounds and vibrator vibrations will be small when the detection distance is getting further. Otherwise, the number of buzzer sounds and vibrator vibrations will significantly value when the detection distance gets closer [6].

- Hardware Design

The hardware design system is divided into three parts, namely Input, Process, Output. Arduino Pro Mini serves to save the program as a whole and serves to manage the output and input systems of the device used. System Hardware Design can be seen in Figure 3

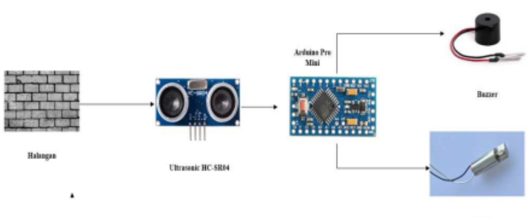

Fig. 3. Hardware Design

Based on Figure 4.2, an obstacle is an object that the ULTRASONIC HC-SR04 sensor will detect. The microcontroller used is Arduino pro mini as a system controller that regulates programs and work tools with output in buzzers [7].

The hardware design in this system is created in a module. In order to properly provide navigate system modules are stored in several positions that can be seen in Figure 4.3.Modul System

- Design Software

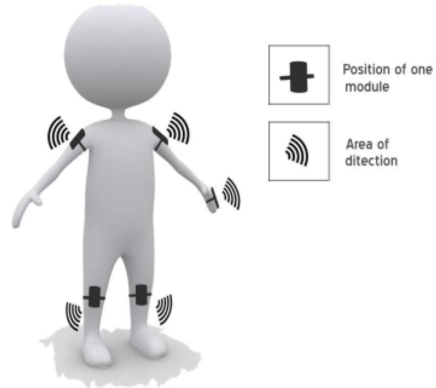

Fig. 4. Position of module

Software design aims to determine each execution flow of the designed system logic. Each input will be received and processed by the software that will later determine the system's output [8]. Here is the flowchart of the system designed in Figure 5

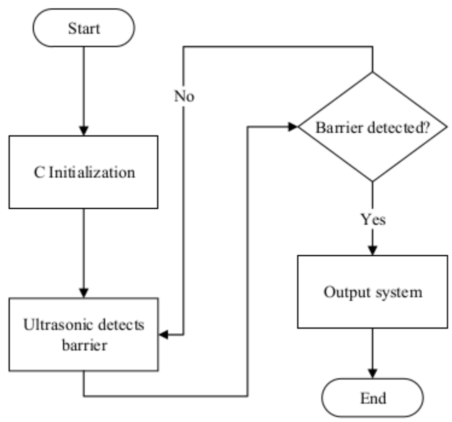

Fig. 5. Software Design

B. Implementation

- Implementation of Arduino Pro mini and Ultrasonic HC-SR04 Sensor

The Ultrasonic HC-SR04 sensor in this study is already a module connected to the Arduino pro mini microcontroller via ports D10 and D12. Arduino pro mini can access the HC-SR04 ultrasonic sensor, process data in real-time with the C programming language. For the HC-SR04 ultrasonic sensor to work in real-time, it must be connected to the Arduino pro mini microcontroller [8].

- Implementation of Arduino Pro mini and Vibrator

The hardware implementation in this study is a vibrator connected with Arduino pro mini through D5 ports. Vibrators connected to the Arduino pro mini microcontroller are system outputs that indicate the system detects obstructions detected by the HC-SR04 ultrasonic sensor. The resulting vibrator output depends on the detection distance the closer the detection, the greater the vibrator vibration intensity. When the distance of the detection is farther away, the vibrator intensity gets smaller.

- Implementation of Arduino Pro Mini and Buzzer

The hardware implementation in this study is Buzzer connected with Arduino pro mini via ports D3. The Buzzer connected to the Arduino pro mini microcontroller is a system output that indicates the system detects obstructions detected by the HC-SR04 ultrasonic sensor. The resulting Buzzer output depends on the detection distance. The closer the detection, the greater the buzzer sound intensity. When the distance of the detection is farther away, the buzzer sound intensity will be smaller [9].

- System Implementation on Human Body

This stage of module that has been created in the previous stage is implemented in the human body. The system module is stored in a predetermined position on the palm, right arm, left arm, right foot, and left foot for the system to navigate correctly. The implementation of the system on the human body can be seen in Figure 6

Fig. 6. Implementation on Human Body

- *Software* Arduino Implementation

The implementation of this software is writing the program by giving commands on ide Arduino software that will be used in detection system by ultrasonic sensor HC-SR04 with output in the buzzer and vibrator. This research using examples and program references taken from the link https://github.com/mdzahiduzzaman/Third-Eye-for-the-blind/blob/master/third-eye_for_the_blind.ino [10]. With the modified third-eye-for-the-blind.ino file name on lines 22-50. The implementation of Arduino software can be seen in Figure 7

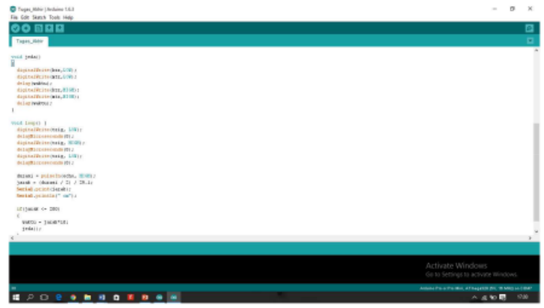

Fig. 7. Implementasi software arduino

IV. Testing And Analysis

A. *Wall Detection Testing*

This test aims to determine which objects can be detected by ultrasonic sensors. This object detection test is performed by testing the system against ten different objects. The parameter being tested is the system state of whether or not to work when detecting an object. Object detection test results can be seen in table I

TABLE I. OBJECT DETECTION TEST RESULT

No	Object	Status
1	Wall	On
2	Mirror	On
3	Wood	On
4	Steel	On
5	Plastic	On
6	Cloth	On
7	Net	Off
8	Paper	On
9	Vehicle	On
10	Human	On

B. *Ultrasonic Sensor Testing and Response Time*

Ultrasonic sensor testing and system response time aims to determine the distance that can be reached by the ultrasonic sensor and the time it takes for the system to detect objects until the system works [11]. This method of testing is calculated directly using the stopwatch at different distances. The test results of system response time can be seen in Table II

TABLE II. RESULT OF SYSTEM RESPONSE TIME TESTING

No	Set Distance (cm)	Status	Delay (s)
1	20	On	0,17
2	40	On	0,2
3	60	On	0,25
4	80	On	0,31

No	Set Distance (cm)	Status	Delay (s)
5	100	On	0,36
6	120	On	0,41
7	140	On	0,48
8	160	On	0,53
9	180	On	1,01
10	200	On	1,13
11	220	Off	-

C. *Buzzer and Vibrator Testing*

This buzzer and vibrator test will determine the number of buzzer sounds, and vibrator shakes at a predetermined time. This method of testing is calculated the number of buzzer sounds and vibrator vibrators within 30 seconds. The buzzer and vibrator test results are in Table III.

TABLE III. BUZZER AND VIBRATOR TESTING RESULT

No	Distance (cm)	Status	Number of Sounds and Vibrations
1	20	On	68
2	40	On	39
3	60	On	26
4	80	On	20
5	100	On	17
6	120	On	13
7	140	On	11
8	160	On	10
9	180	On	9
10	200	On	7
11	220	Off	-

D. *Usage Time Testing*

This usage time test aims to determine the maximum time limit the system can use. This announcement is made using power banks with different capacities of 10000 mAH, 6000 mAH, and 4800 mAH. The testing method is to calculate the time of use of the system until the power bank runs out. Test results of usage timeout can be seen in Table IV

TABLE IV. USAGE TIME TESTING RESULT

No	Power Bank Capacity (mAH)	Time	System Power Load (Watt)
1	10000	15 hours 28 minutes	1,35
2	6000	10 hours 16 minutes	1,22
3	4800	8 hours 43 minutes	1,12
Average			1,23

E. *System Navigation Testing*

This system navigation test aims to find out if the system can provide good navigation. The testing method is to compare the position of the system module with the position of the obstacle. In this test, the system module is stored at several points in the user's body which can be seen in Figure 4.3, and the hitch is placed in a position where the system can detect it. The obstacles used have different highs. high, medium, and low obstacles. High obstacles are obstacles that have a height of more or equal to the height of the user's chest (>= 150 cm), for medium obstacles are obstacles that have a height of higher than the hips and lower than the chest of the user (100 cm – 150 cm) while a low obstacle is an obstacle that has a height of more than the knee and lower than the user's hips (50 cm – 100 cm). The results of system navigation tests on high barriers can be seen in table V

TABLE V. SYSTEM NAVIGATION TEST RESULT ON HIGH

No	Modul Position	Barrier Position		
		Hight (>=150 cm)		
		Front	*Right*	*Left*
1	Palm	On	Off	Off
2	Right Arm	Off	On	Off
3	Left Arm	Off	Off	On
4	Right Foot	On	On	Off
5	Left Foot	On	Off	On

From Table V it can be known that the test was done using high object. The results of system navigation tests on medium obstructions can be seen in table VI

TABLE VI. SYSTEM NAVIGATION TEST RESULT ON MEDIUM

No	Modul Position	Barrier Position		
		Medium (100 cm – 150 cm)		
		Front	*Right*	*Left*
1	Palm	On	Off	Off
2	Right Arm	Off	Off	Off
3	Left Arm	Off	Off	Off
4	Right Foot	On	On	Off
5	Left Foot	On	Off	On

From Table VI, it can be known that the test was done using a medium hitch. The results of system navigation testing on low hitches can be seen in table VII

TABLE VII. SYSTEM NAVIGATION TEST RESULT ON LOW

No	Modul Position	Barrier Position		
		Medium (100 cm – 150 cm)		
		Front	*Right*	*Left*
1	Palm	Off	Off	Off
2	Right Arm	Off	Off	Off
3	Left Arm	Off	Off	Off
4	Right Foot	On	On	Off

No	Modul Position	Barrier Position		
		Medium (100 cm – 150 cm)		
		Front	*Right*	*Left*
5	Left Foot	On	Off	On

From the system navigation testing table, please note that the positioning of the system module on the palm serves to detect high obstacles (>= 150 cm) and medium obstacles (100 cm – 150 cm) located in front of the user, for system modules on the right and left arms to test the high obstacles located on the right and left of the user, while the sensors in the system modules placed on the right and left legs are directed diagonally in order to detect moderate obstructions and things low wishful thinking (50 cm – 100 cm) located in the front, right and left. In this test, the On and Off description shows that the system is working or not. In this test, it can be known that the user navigates by avoiding obstacles detected by the system. For example, when the system module located in the palm and right arm detects the object, the user can walk, avoiding the object to the left because the object is detected in front and right of the user.

F. Analysis

In the research that has been done obtained results in the form of obstruction detection by ultrasonic sensors where testing is conducted against ten different obstacles. In this test, the sensor can detect almost any object except a hollow object such as a net.

System delay calculation is performed in the system response time test when the sensor detects the object until the system is working. The ultrasonic sensor will detect at a predetermined distance of 20 cm - 300 cm in this test. The system response time test results can be known that the longer the sensor detection distance, the greater the delay in the system. This system cannot work when the detection distance of an obstruction object is more significant than 200 cm.

Buzzer and vibrator testing is performed by calculating the frequency of sounds and vibrations. Calculations are performed at a distance of 20 cm – 200 cm and performed in 30 seconds. From this test, the longer the detection distance, the smaller the number of buzzer sounds and vibrator shakes. On the contrary, the closer the detection distance, the greater the buzzer sounds and vibrator vibrations. This is because the system is designed so that users can estimate the distance of obstacle objects.

The test of the usage time limit is done to calculate the maximum time limit of system usage. Testing is performed when the system is in use until the resources are used up. This test uses three different power bank resources with 10000 mAh, 6000 mAH, and 4800 mAH. Based on this test, the more significant the capacity of the power bank, the longer the usage time. In this test, it can also be known that the system has a significant average power load of 1.23 watts

The system navigation test is done by placing obstacles in a position where the system can detect them. The obstacles used have different highs, i.e., high and low obstacles. High obstacles are obstacles that have a height of more or equal to the user's height (>= 150 cm). In contrast, low obstacles have a height of more than the knee and lower than the user's hips (50 cm – 100 cm). This test is also done by placing the obstacle's position in front, right, and left of the user. This is done so that the user can know the obstacle's position and avoid it. Based on this test, it can be known that the system can detect obstacles in front of it and can help users navigate if the system module is placed at a specified position.

The results of the overall system analysis found that the system will work at a distance of less than or equal to 200 cm. At a distance of more than 200 cm, the sensor can still detect obstacles. However, the system will not work because the system will work when the sensor detects an obstacle at a predetermined setpoint of 200 cm. The system is called working when the buzzer makes a sound, and the vibrator vibrates. Buzzers and vibrators will work when it gets a voltage supply from the Arduino. The system is controlled using the microcontroller Arduino pro mini with the C programming language.

V. CONCLUSION

The conclusion of this study was the design of visually impaired navigation aids using ultrasonic sensors with buzzers and vibrators as actuators using Arduino pro mini as the center of the system and C language as its programming language.

The test results showed that the buzzer and vibrator could run when the sensor detects an obstruction distance of less than or equal to 200 cm and is processed by an Arduino pro mini to transmit the voltage supply to the buzzer and vibrator.

The design of the blind navigation tool system was successfully carried out by placing the position of the system module on the user's body which has a power load of 1.23 watts.

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