BINDURA UNIVERSITY OF SCIENCE EDUCATION FACULTY OF SCIENCE AND ENGINEERING DEPERTMENT OF COMPUTER SCIENCE

A SMART ULTRASONIC STICK FOR VISUALLY IMPAIRED PEOPLE

By

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APPROVAL FORM

The signatories confirm that they supervised Blessing Chikonhi’s dissertation, which was submitted in partial fulfilment of Bindura University of Science Education's requirements for a Bachelor of Computer Science Honors Degree.

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Abstract

This paper reports on a study that helps visually impaired people walk more confidently. The study hypothesizes that a smart ultrasonic cane that alerts the visually impaired to obstacles ahead could help them walk with less accident. The aim of the post is to deal with the development work on a smart device that could communicate with users through a sound notification, which is called the Smart Ultrasonic Stick.The smart stick is supposed to use. Arduino UNO, Ultrasonic Sensor, LED and Buzzer module. Arduino is a microcontroller which can do all the calculations very easily and quickly with great accuracy. Ultrasonic sensor is used to detect the object in the front of the person by measuring the distance between the object and the stick. The Buzzer Module, is used here is to alert the person by making sound, this in return helps the user to reach his /her destination safely. A series of tests have been carried out on the smart stick and the results are discussed. This study found that the Smart Stick functions well as intended, in alerting users about the obstacles in front.

Dedication

This paper is dedicated to my parents and my family for their loving support.

Acknowledgements
All credit for finishing this dissertation belongs to the Almighty God, and special appreciation to my supervisor, Mr Chikwiriro and co-supervisor Mr Mzurura, for their assistance. Also, I'd want to thank my parents for their unwavering support from the beginning.

Contents

Chapter 1 : INTRODUCTION

1.1 Introduction

The eyes, the organs of vision, are a critical part of human physiology because of their ability to receive and process visual details in the brain. In expansion, they play an essential role in people's lives, as 83% of data from the environment is received through the eyes . In any case, there are a few individuals in the world who are denied this. There are a number of extreme disabilities, one of which is visual deficit, in which an individual would face many problems despite a number of mechanical advances. Visual impairment can be a condition where a person is unable to see and has no ability to distinguish light. In addition, visual impairment hits those who have so little vision that they use other abilities as sight substitution abilities. Externally disabled is therefore considered an individual who is responsible for an accident with vision or a partial accident.

1.2 Background

Globally, blindness affects a large percentage of the population. The World Health Organization (WHO) estimates that there are 285 million visually impaired, 39 million blind and 246 visually impaired people worldwide. The percentage of visually impaired people worldwide exceeds 90%. Blindness is the curse of the poor. All daily tasks, including going outside, require assistance. Most dazzling individuals have a place to rant or create nations, most in Africa and Asia. From later findings, it is expected that by 2050 the rate of visual impairment may triple due to rapid population growth and adolescence. By considering these components (age and money status), we tried to streamline the characterized problem and outlined a structure that is lighter, successful and not complex in structure, so it is easily portable and reasonable, for the most outwardly affected individuals. In today's age of innovation, a flood of untapped and imaginative innovations provide numerous possibilities for everyone to live a more comfortable life. For dazzling individuals, many aids have been created by many analysts to ensure a free life. Some of them have a number of modern features, but they are costly, so most people with external challenges (VIP) cannot afford these kinds of gadgets. On the other hand, less expensive gadgets lack certain essential strengths. Our proposed gadget may not look appealing but our focus was to reach the fiscally weaker VIPs so that they can utilize and benefit from it. This proposed gadget has certain advantages that support VIPs in moving freely around their environment.

1.2 Research Problem

A total of 217 million people have moderate to severe visual impairment, 36 million are visually impaired and 253 million people live with visual impairment. 81% of people with visual impairment are over 50 years old (2019 WHO estimate). Our main goal is to help the blind and improve their quality of life. This can be achieved by using the latest smart stick technology.

1.3 Aim of the study

The goal of this project is to design and build a smart ultrasonic stick for visually impaired people.

1.4 Objectives of the study

1. To design and build a smart ultrasonic stick for visually impaired people.
2. The smart stick must be able to relay output through a beeping sound.
3. To assess the effectiveness of using ultrasonic sensors in detecting obstacles.

1.5 Research Questions

1. How will the smart stick be working?
2. How can smart stick improve the lives of blind people?
3. To what extent is the proposed system efficient and effective in helping the blind people?

1.6 Significance of study

It is difficult for visually impaired people to communicate and perceive their surroundings. They do not interact much with their surroundings (Terlau, 2015). Because it can be difficult for the visually impaired to distinguish obstacles in their way, and because they cannot move from one place to another, physical movement can be difficult for them. Therefore, it will be much easier for blind individuals to manage and move if we use available technology. This technology will help all blind people. It serves as a reminder of the many real-world opportunities available to the blind. In order to develop one's talents, a project often opens a number of doors to be explored further.

1.7 Scope of work

This work focuses on the design and implementation of a smart ultrasonic stick for visually impaired people. The scope of the project includes the following;

- Analysis of the existing system
- Review of past works on proposed topic
- Design of the proposed system
- Construction and Implementation of the proposed system

1.8 Justification of Study

Visually impaired individuals have a parcel troubles in adjusting to the environment. With the assistance of this proposed framework the chances of the visually disabled individuals to look for help from other individuals can be enormously decreased. This subsequently gives them with a capacity of openly depending on themselves in most cases. Add up to reliance on other individuals for help all the time can ended up obnoxious most times since not all people have a making a difference heart and so they may conclusion up being injurious towards the visually impaired.

Chapter 2 : LITERATURE REVIEW

3.0 Introduction

As a result, technology can help reduce many of the barriers that people with disabilities face. Assistive technology is the name for these technologies (AT). There are many different types of disabilities such as visual, hearing and physical disabilities. They got help thanks to AT. However, ATs are expensive to build, which increases their selling price.

3.1 Smart stick

Is a device that helps blind and visually impaired people recognize objects and communicate information to them. It also improves understanding of the environment as less human effort is required (Ray, 2017).

3.2 Sensors

A sensor could be a gadget that produces a yield flag to sense a physical event. In the broadest sense, a sensor is a gadget, module, machine, or subsystem that detects events or changes in its environment and transmits the information to other hardware, usually a computer processor. Constantly use sensors in conjunction with other gadgets. Sensors are used in a number of common items, including touch-sensitive lift buttons (also known as material sensors), lights that turn on or off by touching the base, and many other things that the majority of individuals never actually do bear in mind. Sensor applications have evolved beyond the conventional disciplines of temperature, mass, and current estimation, for illustration into MARG sensors, which are highly regarded for advances in micromachines and user-friendly microcontroller stages (Bennett, 1993).

3.3 Classification of Sensors

- Active and Passive Sensors
- Analog and Digital Sensors

3.3.1 Active Sensors

Dynamic sensors are types of sensors that use an external source of excitation to produce a yield signal. The inherent physical properties of the sensor change depending on the applied external impact. As a result, it is additionally known as self-generating sensors.

3.3.2 Passive Sensors

Passive sensors are a type of sensor that produces a yield signal without the aid of an external excitation source. They do not require any additional boost or voltage.

3.3.3 Analog Sensors

Analog sensors are those that provide a continuous signal with respect to time and analog output. The measured value or input given to the framework decides how much of the analog output is generated. Regularly, the output is a current or analog voltage in the range up to 5 V. Cases of continuous signals include various physical parameters such as temperature, stretch, weight, rooting, etc.

3.3.4 Passive Sensors

A passive sensor is a gadget that picks up input from the outside world and reacts to it. Through the detection of vibrations, light, radiation, heat, or other phenomena occurring in the subject's environment, passive sensor technologies collect target data. They stand in contrast to active sensors, which use transmitters to convey a signal, a wavelength of light, or electrons that are then reflected off the target and collected data by the sensor.

3.4 Ultrasonic Sensors

Are devices that generate or detect ultrasonic energy. Transmitters, receivers and headphones are three broad groups into which they can be divided. Receivers convert ultrasound into electrical signals, transmitters convert electrical signals into ultrasound, and mobile devices can both transmit and receive ultrasound (Tolerate, 2020).

3.5 Review of past work

In recent years, there have been several designs of smart stick systems based on different modules. Due to the proliferation of modern technology, these days, the world is increasingly experienced the use of wireless devices.

Like (Mazo and Rodriguez, 2018), the dazzling stick is one of the assistive tools for the visually impaired and is really vital. According to (Herman, 2015) one of the biggest problems of the visually impaired is that most of these individuals have misplaced their physical integrity. Moreover, they do not have confidence in themselves. This explanation was demonstrated by (Bouvrie, 2016) in which a test called "Project Prakash" was carried out. When testing the visually impaired, they were expected to use their brains to distinguish a set of objects. According to (Chang and Tune, 2015) it can also be related to various circumstances. When the visually impaired enter a modern environment, they find it difficult to remember areas of questions or obstacles. These illustrations illustrate the difficulties of visually impaired individuals.

The walking stick is designed to help visually impaired users move safely and quickly between obstacles and other hazards. The guide stick is used as a widely used white stick where the user holds the guide stick in front of the user while walking. The guide stick is significantly heavier than the white stick because it uses a servo motor. The wheels are equipped with encoders to determine the relative movement. A servo motor, controlled by a built-in computer, can steer the wheels left and right relative to the stick. To detect obstacles, the guide stick is equipped with ten ultrasonic sensors. A mini-joystick located on the handle allows the user to determine the desired direction of movement. The guide stick is much heavier than a regular white stick and is also difficult to maintain because it cannot be folded.

The Shrewd Cane is one development that was originally a creation of an ordinary stun cane, but is prepared with a sensor frame. This innovation follows on from the Direct Cane, where this development includes a range of ultrasonic sensors and servo motors. This development is planned to help the daze in discovery. Ultrasonic sensors must be distinguished and maintain a strategic distance from deterrents or objects found in front of the client. Meanwhile, the fluffy controller has to decide on the enlightenment that will be done to make the case turn right, clear, or stop. Like the Direct Cane, this development additionally includes a control button on the handle, and the button has four different headings. This innovation has the same shortcomings as the Direct Cane, where there will be a problem with the reserve of space or the placement of the savvy cane. In addition, fetched is additionally lacking in this enterprise because it uses ultrasonic sensors and a series of servo motors. In case the toll collected is also high, the clients cannot bear it because the regular wage

Students from Central Michigan University have created a Smart Cane that uses Radio Frequency Identification (RFID). RFID is used to control people by detecting RFID tags that have been placed in various locations and by detecting objects or obstacles in front of the user. This device resembles a standard cane, but comes with a bag that the user carries. The innovation is powered by electricity from the bag, which also houses speakers to alert the user. There are special gloves that vibrate each finger for users who cannot hear, and the different vibrations in each finger have different meanings. However, this device has a number of disadvantages and is only suitable for small areas. This is because the device only works as a standard blind stick outside of the area where the RFID tag has been placed. If this invention is used in an outdoor environment, it will also be expensive because a larger area will need to be marked, which will increase the cost.

The Mechatronic Blind Stick is a guidance system designed to make everyday work easier for visually impaired people. This invention has many similarities with the Smart Blind Cane. In which this invention uses ultrasonic sensors and sound vibrations. However, this invention also has several weaknesses; it cannot be folded and is difficult to maintain. In addition, this invention is not equipped with sensors for detecting water bodies. There may even be an infrared smart blind.

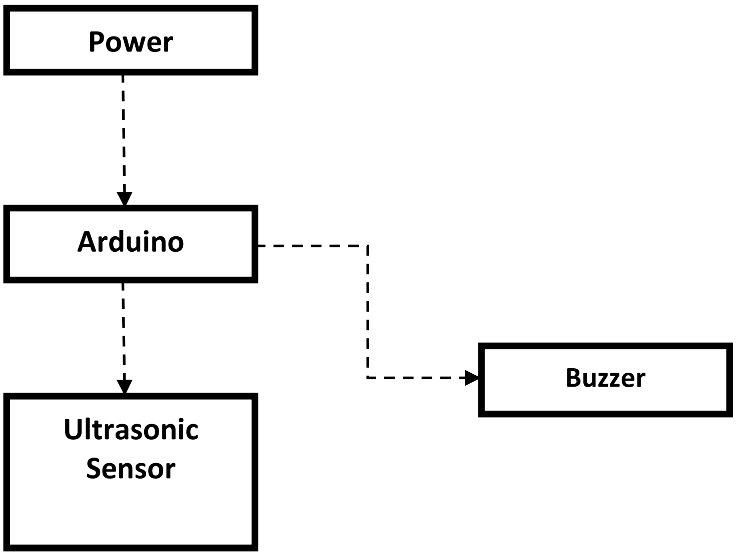
A lot of study and research is being done to design a good tool that will give the user a better walking experience. One of them is Smart Vision. It is an efficient design that can detect path boundaries using an edge detector and a modified version of the Hough transform. The device can detect both stationary and moving obstacles. The former is performed using a camera attached to the user's chest, and the latter is achieved using multi-level, annotated, bio-inspired keypoints. Further work was done by (Fernandes, Costa, Filipe, Hadjileontiadis, & Barros, 2019)

The device can detect specific landmarks and will inform the user the distance from the obstacle. Depths are identified using two cameras which generate images suitable to extract both the position and distance of objects according to their relative brightness. HALO is another device that can be mounted on the existing white can and can detect low hanging obstacles such as branches of trees (Katherine, 2013). It
Consists of ultrasonic range sensor with an eccentric-mass vibrating motor which vibrates distinctly for ground obstacle and low hanging obstacle. An intelligent guide stick detects obstacles using ultrasonic sensors but it is unable to tell whether the obstacle is in motion or not (Kang, 2015).A wireless ultrasonic ranging system detects obstacles using an ultrasonic sensors and the PIC16F877 microcontroller finds out the distance from the obstacle (Tahat, 2001). The phone that is linked to the microcontroller converts the information to speech and the data is sent to the Bluetooth earphone to alert the user. In the work by (Amirhossein Tamjidi, Cang Ye and Soonhac Hong, 2012) a portable indoor localization aid for 6 Degree of Freedom device post estimation is proposed.

This technique serves as an internal GPS system for visually impaired people to determine their location. In addition, it helps in the recognition of obstacles and supports the mobility of the blind. Another paper (C. Ye and X. Qian, 2017) proposes a RANSAC-based plane detection approach where the accuracy is guaranteed by the complex geometry of the 3D data. Using this technique, a robotic navigation system would help the blind. "Augmented White Cane with Multimodal Haptic Feedback" by (S. Gallo, D. Chapuis, L. Santos-Carreras, Y. Kim, P. Retornaz, H. Bleuler, and R. Gassert,2010) uses haptic feedback to simulate behavior in longer rods. The shock generating module serves as a feedback source and releases the stored kinetic energy of the rotating wheel in a controlled manner. In the case of a moving obstacle, the spatio-temporal vibration pattern stimulated on the user's hand creates a sensation of apparent movement. A different approach can be seen in the work presented by (Larisa Dunai, Guillermo PerisFajarnes, Victor Santiago Praderas, Beatriz Defez Garcia, 2016) on "Prototype real-time assistance - a new navigation aid for the blind", which includes stereo vision technology integrating real-time detection of static and moving obstacles and free lanes. The system offers three-dimensional information about the environment and transmits it to the user through the transmission of acoustic signals. The device consists of a helmet equipped with a pair of stereo cameras that captures the image. The image is processed by a laptop and the user is alerted via headphones.

Main features of system

Figure 2.1 shows block diagram



Chapter 3 : METHODOLOGY

3.0 Introduction

The aim of this chapter is to define the strategies and tools used to achieve the proposed objectives of research and system. With the help of the information attained in the previous chapter the author will formulate the necessary methods to build a solution and be able to make choices among competing strategies to achieve the expected results of the research.

3.1 Research Design

Research design should be a reflexive process operation through every stage of a project. The design stage involves coming up with the different modules of the system and their intended functionality. The core objective of this stage is to ensure that an operative, proficient, sustainable and reliable model of the system is designed. The researcher used c programming language, a laptop, a serial printer cable, Arduino board, ultrasonic sensor and a half bread board to develop the system. The author used documentation and record to gather data about smart ultrasonic stick for visually impaired people. The author decide to use the experimental research design as it allows him to observe changes and response of systems and objects as he changes or adjust factors.

3.1.1 Requirements Analysis

At this point, it is essential to record all the functional and non-functional specifications of the required system. It is advisable to structure all incoming data, asses it, consider all the limitations which may arise on the customer's side, and come up with a ready-to-follow specification that meets the customer's needs. The research also took into account any type of limitations, such as moment and budget restrictions, that may impede the design method.

3.1.1.1 Functional Requirements

- The system ought to be able to detect objects.
- The system should be in a position to warn the visually impaired person.
- The system should be able to alert the others on the surrounding.

3.1.1.2 Non-Functional Requirements

- The system ought to be able to detect an object as quickly as possible.
- The system is supposed to be easy to use.
- The system should be available all the time and should be able to detect objects anytime.
- The system should have a relatively small response and decision time

3.1.1.3 Hardware Requirements

- Arduino R3 micro-controller
- Half Bread board
- Connection wires
- USB type B cable
- Ultrasonic Sensor
- Buzzer
- Led
- Battery

3.1.1.4 Software Requirements

- Windows 10 Operating system
- Arduino IDE

3.2 System Development

This system describes the overview of the system and how it was developed so as to produce the results. It specifies all the software tools and models used in the development of the system.

3.2.1 System Development tools

A methodology for software production or system design in software engineering is a framework for structuring, planning and controlling the methods of creating an information system. Researchers have identified many frameworks for different projects and each framework has its own strengths and weaknesses according to its application. Some of these frameworks include the waterfall model, the spiral model and the progressive (prototyping) model. The author decided to use the waterfall model due to its simplicity since the project is relatively small and has a strict time frame. All the requirements of the project have been identified and all the tools are in place hence the waterfall model is the best candidate for such a project.

3.2.2 Waterfall Model

This model, which is among the more traditional and basic, has six stages of system development. It starts with the first stage and falls down like a waterfall, suggesting that it is rigid and linear in its development approach and prohibits going back or hearing feedback (Chandra, n.d.). Each design phase in the system has a different goal and once one phase is completed there is no going back. The author first connected all the necessary parts to the microcontroller, Arduino UNO, using a breadboard. The Arduino UNO was the main component needed for the other stages of the project to commence. The stages involved installing the ultrasonic sensor, the led light, the buzzer and the 9v battery with connecting wires to the micro controller.

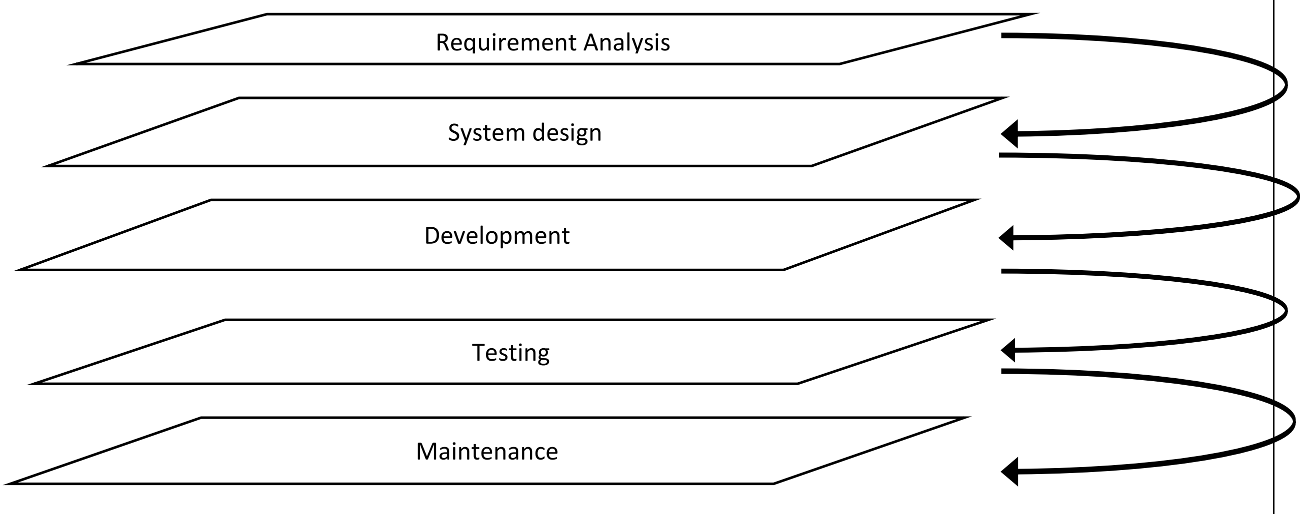


Figure 1 Waterfall Model

Apart from the methodology the system was also developed using the following tools:

1. C

   Is a high level programming language, the author used the C language as the Arduino IDE is based on the C programming language.

3.3 Summary of how the system works

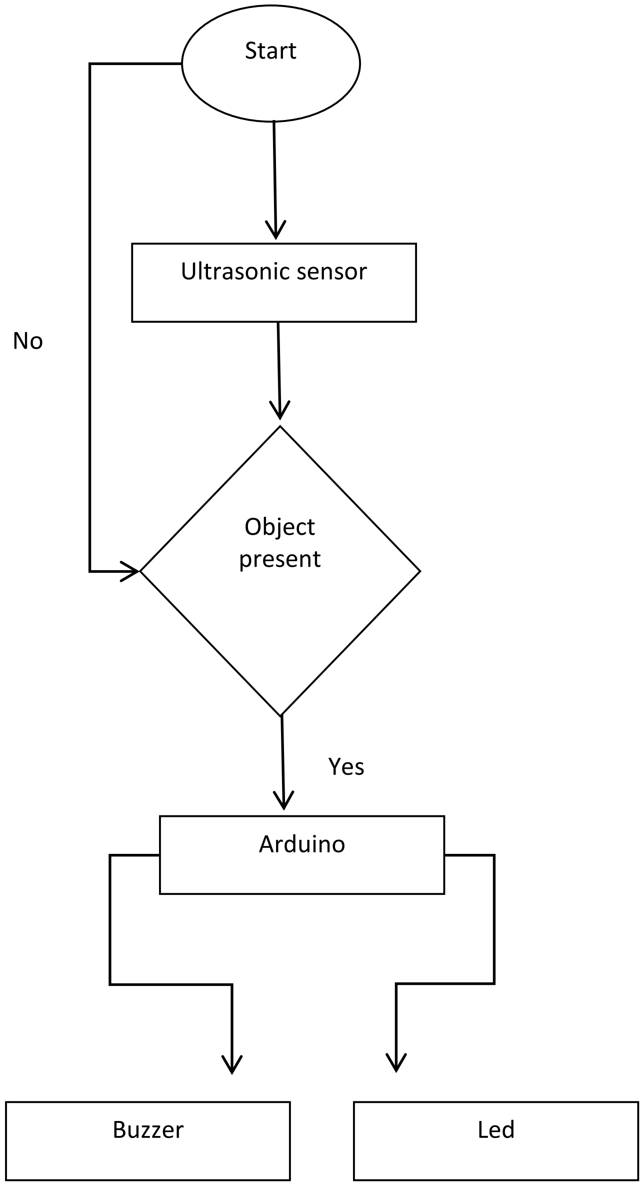
The Arduino UNO is the main component of our project as it is the micro controller which takes input from the ultrasonic sensor and gives corresponding output on the other components. A 9V battery is used for the power supply and a switch is used to control the supply. As we switch on the stick, the stick gets activated a led will glow until the power supply is given. At the bottom of the stick ultrasonic sensor is placed which will detect the obstacles. The range of the ultrasonic sensor is kept to be 20cm in our project. When the ultrasonic sensor detects the obstacle in the given range an analogue signal is sent to the Arduino from the sensor. An in-built ADC in the micro-controller converts the analogue detection signals into digital signals. For a detectable obstacle, a digital high (1) is transmitted. A digital low (0) is transmitted for non-detection. In this way the transfer of data from the sensor to Arduino and from there to the buzzer and LED glows. If the obstacle is found the buzzer starts alerting the user. As the stick is moved away from the obstacle the buzzer stop alerting. This leads to less accidents as the user are alerted and may be safety measure.

3.4 System Design

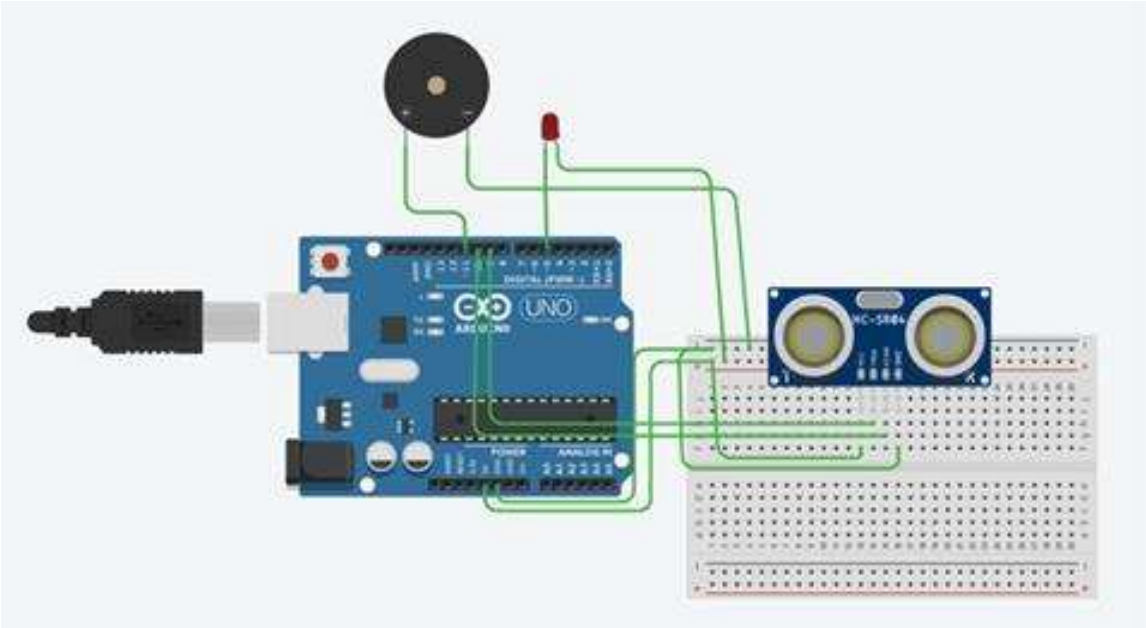
The requirements specification document is analyzed and this stage defines how the system components and data for the system satisfy specified requirements.

3.4.1 Proposed System flow chart

Flowcharts are an efficient way of bridging the communication divide between programmers and end users. They are flowcharts specialized in distilling a significant amount of data into comparatively few symbols and connectors.



3.4.2 Solution Circuit



Circuit of the system

3.4.3 Ultrasonic Sensor

Ultrasonic sensors are used primarily as proximity sensors. They can be found in automobile self-parking technology and anti-collision safety systems. Ultrasonic sensors are also used in robotic obstacle detection systems, as well as manufacturing technology.

Figure3. Ultrasonic Sensor

3.4.4 Buzzer

Magnetic buzzers operate using electromagnetic principles. When power is applied, current runs through the coil of wire inside the buzzer, which produces a magnetic field. The flexible ferromagnetic disk is attracted to the coil when the magnetic field is activated, then returns to rest when the magnetic field is off.

Figure 3.5 Buzzer

3.4.5 Arduino Uno

According to (Barragán, 2016) the Arduino Uno is an open-source microcontroller board designed by Arduino.cc and based on the Microchip ATmega328P microprocessor. The board has digital and analog input/output (I/O) pins that can be used to connect to expansion boards (shields) and other circuits. The board features 14 digital I/O pins (six of which are capable of PWM output), 6 analog I/O pins, and is programmable through a type B USB cable using the Arduino IDE (Integrated Development Environment). It can be powered by a USB cable or an external 9-volt battery, with voltages ranging from 7 to 20 volts. It's similar to the Arduino Nano and Leonardo microcontrollers.

Figure 3.6 Arduino Uno

3.4.6 Connecting wires

These wires typically come in three versions: male-to-male, male-to-female and female-to-female. The difference between each is in the end point of the wire. Male ends have a pin protruding and can plug into things, while female ends do not and are used to plug things into.

Figure 3.7 connecting wires

3.4.7 LEDs

LED is a semiconductor light source that produces light when electric current flows through the diode. These diodes are widely used due to their effectiveness in terms of low power consumption, longer shelf life, and better illumination. There are various types of LEDs made and are classified into different categories.

Figure 3.8 LEDs

3.4.8 Breadboard

A breadboard, or protoboard, is a construction base for prototyping of electronics. It is not necessary to solder the breadboard because it is reusable, David (2014). This makes it simple to use for making temporary prototypes and circuit design experiments. As a result, solder less breadboards are becoming increasingly popular among students and in technology education.

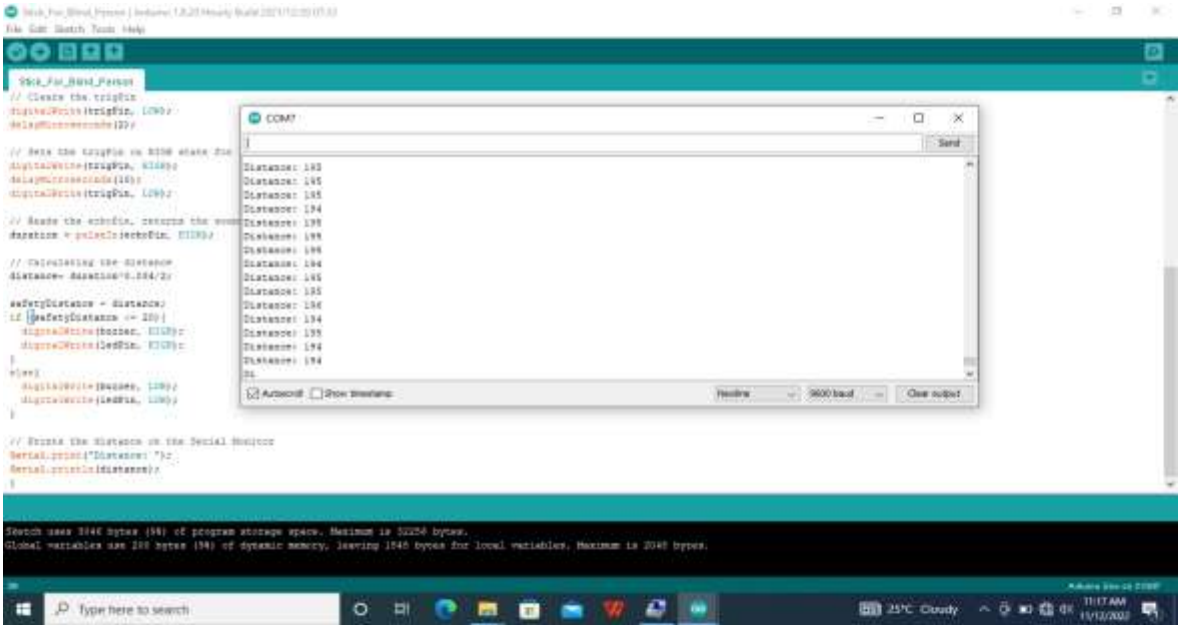
Figure 3.9 Breadboard

3.5 Data collection methods

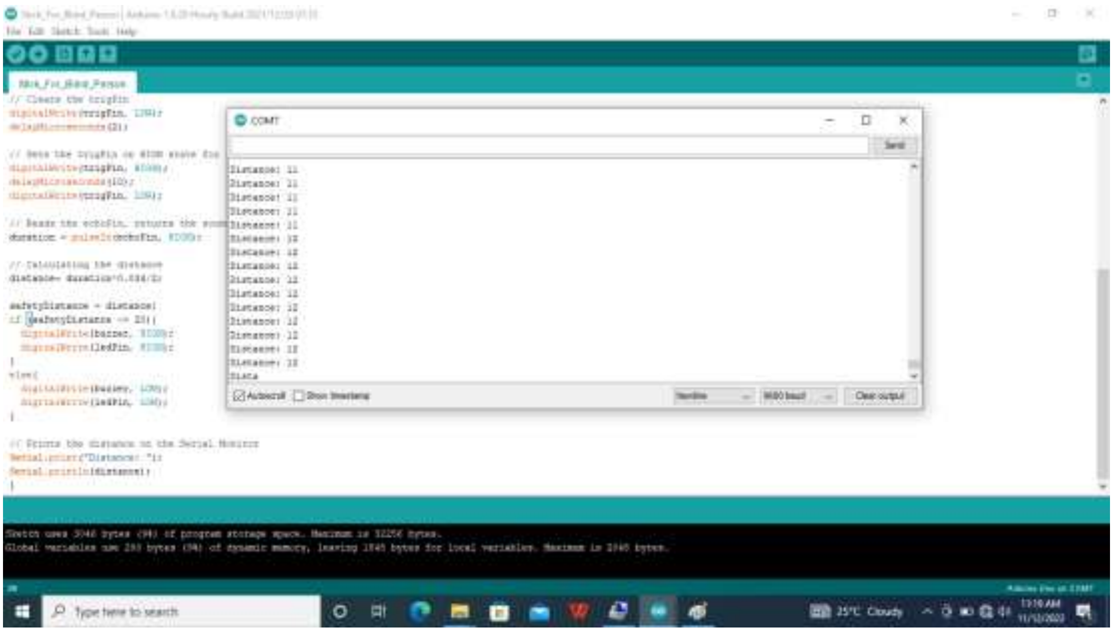
The author used observation as a data collection tool. The author run multiple cycles and exposed the system to different scenarios and observed how it responded. Observation gave the researcher room to analyze the accuracy of the system and the response time of the solution.

3.6 Implementation

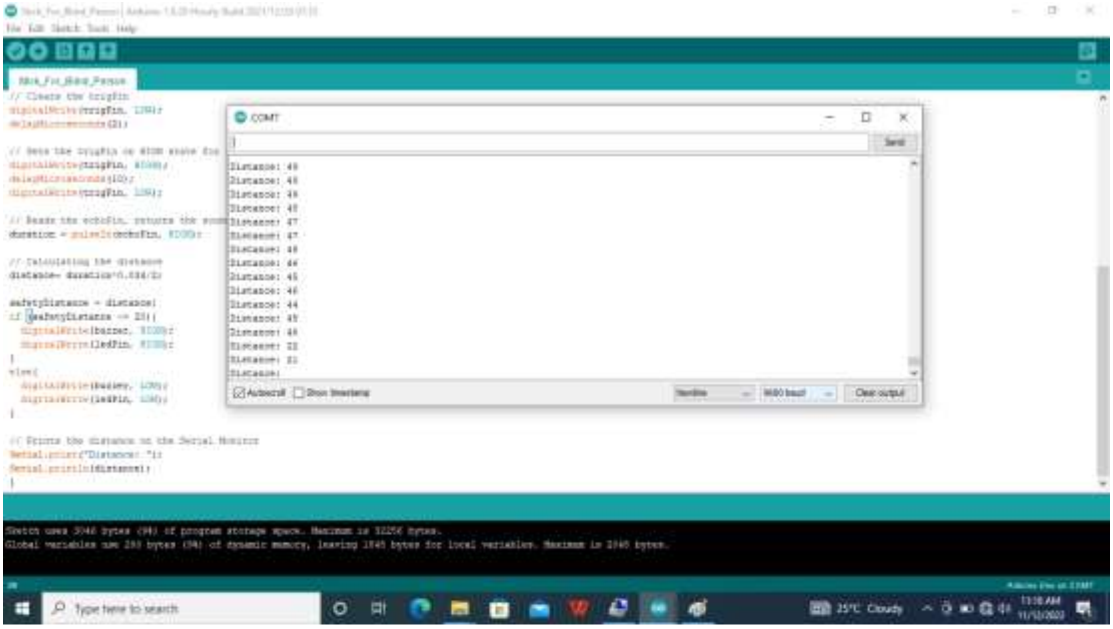
The system is now detecting objects.



Screenshots of the ultrasonic sensor at its maximum range



Screenshots of the ultrasonic sensor detecting objects at range of 21cm



Screenshots of the ultrasonic sensor detecting objects at range of 49cm

3.7 Summary

This chapter mainly focused on the methodology used in the development of the system and how it was designed. Different techniques were used to come up with the system, also different tools like the c and the Arduino interface made it possible to come up with the proposed solution. The system functionalities and how the system data flows from the start to the end are as well illustrated in this chapter. The results obtained from the developed solution where discussed and analyzed in the following chapter. The next chapter also draws a conclusion on the obtained results

Chapter 4 : RESULTS

4.0 Introduction

The need to analyze the efficiency of the developed solution comes after the completion of the system. Accuracy, performance and response time were the matrices used to determine the efficiency and effectiveness of the developed solution. Data collected in the previous chapter was analyzed to produce meaningful results. The developed system’s behavior was as well observed under different conditions and the outcome was presented in a table format. The white box, black box and unit testing play major roles in determining the system behavior in different conditions.

4.1 Testing

Testing is an essential part of the development process and this chapter shows the test that were undertaken and the results the produced. The testing is measured against the functional and the non-functional requirements of the proposed solution.

4.1.1 Black box Testing

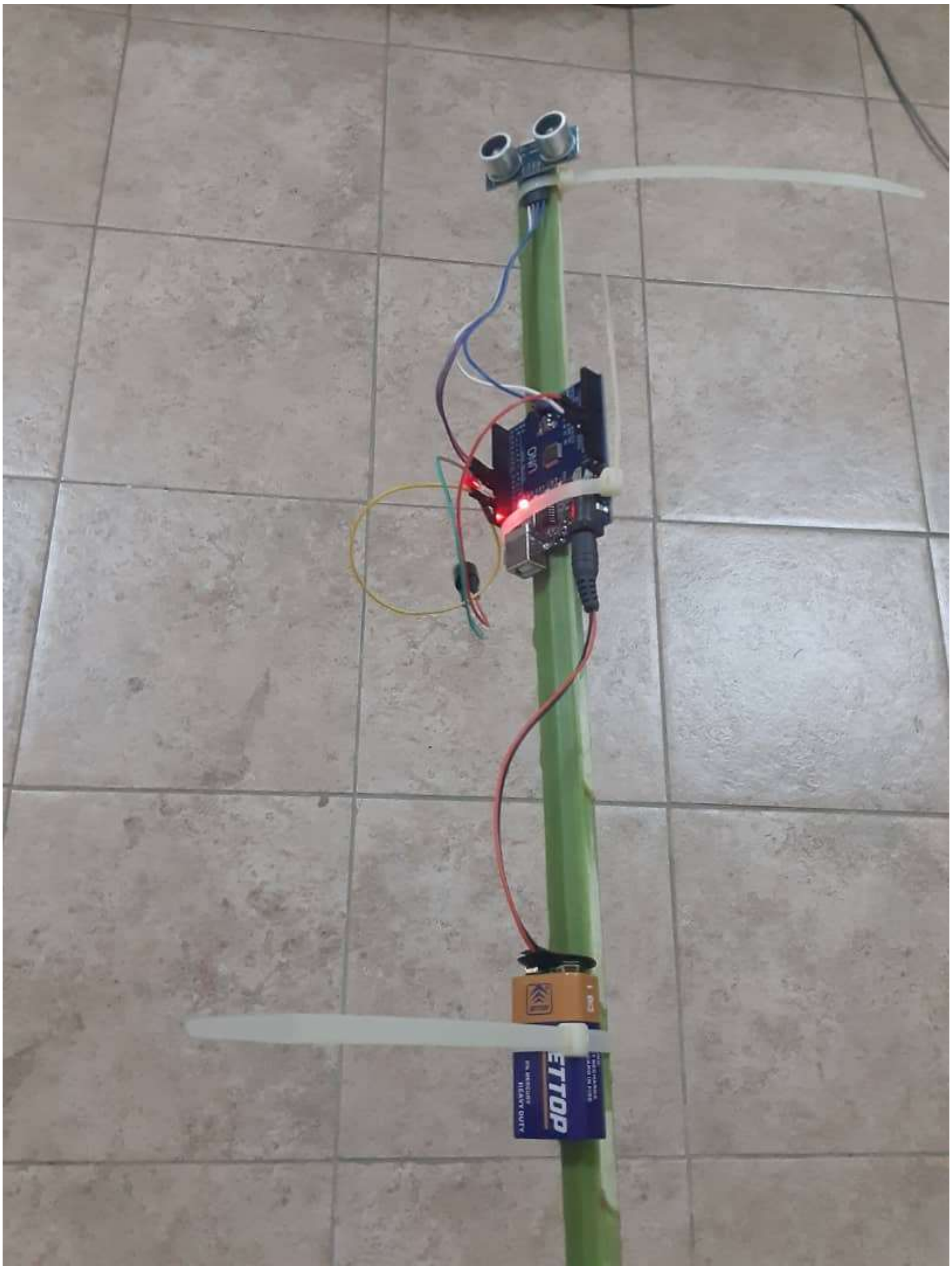
Black box testing allows a person without the knowledge of the internal structure of the system to test it against the functional and sometime the nonfunctional requirements of the system. The supervisor and some students carried out the black box testing of the system, illustrated below are some or the outcome of the tests.

```
pinMode(echoPin, INPUT); // Sets the echoPin as an Input
pinMode(buzzer, OUTPUT);
pinMode(ledPin, OUTPUT);
Serial.begin(9600); // Starts the serial communication
}

void loop() {
// Clears the trigPin
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin, HIGH);

// Calculating the distance
distance= duration*0.034/2;

safetyDistance = distance;
if (safetyDistance <= 5){
  digitalWrite(buzzer, HIGH);
  digitalWrite(ledPin, HIGH);
}
else{
  digitalWrite(buzzer, LOW);
  digitalWrite(ledPin, LOW);
}

// Prints the distance on the Serial Monitor
Serial.print("Distance: ");
Serial.println(distance);
}
```

Code of the prototype

```
// defines pins numbers
const int trigPin = 9;
const int echoPin = 10;
const int buzzer = 11;
const int ledPin = 13;

// defines variables
long duration;
int distance;
int safetyDistance;


void setup() {
pinMode(trigPin, OUTPUT); // Sets the trigPin as an Output
pinMode(echoPin, INPUT); // Sets the echoPin as an Input
pinMode(buzzer, OUTPUT);
pinMode(ledPin, OUTPUT);
Serial.begin(9600); // Starts the serial communication
}


void loop() {
// Clears the trigPin
digitalWrite(trigPin, LOW);
delayMicroseconds(2);

// Sets the trigPin on HIGH state for 10 micro seconds
digitalWrite(trigPin, HIGH);
delayMicroseconds(10);
digitalWrite(trigPin, LOW);

// Reads the echoPin, returns the sound wave travel time in microseconds
duration = pulseIn(echoPin, HIGH);

// Calculating the distance
distance= duration*0.034/2;

safetyDistance = distance;
```

Second part of the code


Screenshot of the prototype

4.2 Evaluation Measures and results

For the evaluation of results, metrics like Precision, Recall, F1 score and Accuracy are calculated using different scenes to the system. The performance of the system is ranked according to its ability to determine whether there is an object or not, the time it take to determine the presence of an object and the rate of false object detection in different environment after a training session. To test for the accuracy of the system the author used the confusion table show in table 1 below. The control that was created by the author set bench marks of accuracy at 56 % for object detection. It gave response time of approximately 4 seconds for object detection in a controlled environment. The reading where read with an imposed delay of 400 milliseconds.

Table 1 Confusion Metrics

Type	Object Present	Object not Present
Object Present	True Positive	False Negative
Object not Present	False Positive	True Negative

One scene and test environment was created for observation of the system. On the scene the system was observed on 40 occasions 20 with an object and 20 without an object and the behavior of the system was observed. The scene where there is an object and the other where there is no object. All the analysis on the scenes was carried out to test for the solution's accuracy and elimination of false detection. The table below show the observed results from the tests carried out.

Table 2 Object detection test carried out

Test cases	Object Present	**Number of tests**	**Correct readings**	**False Readings**	**Classification**
1	Yes	20	20	0	True positive
2	No	20	18	2	True negative

4.2.1 Accuracy

Accuracy is the number of right predictions divided by the total number of forecasts in each category. It is then multiplied by 100 to get the percentage of correctness. It is calculated using the equation below:

Equation 1: Accuracy calculation as adopted from Karl Pearson (1904)

Accuracy = (TP+TN)/ (TP+TN+FP+FN)*100

Accuracy = (20+18)/ (20+18+2+0)

=0.95*100

= 95%

4.2.2 Response Time

Response time refers to the time it takes the system to sense and decide there is an object in the environment. It is used as a measure of system performance. To test for the system response time the author used the average and the peak response times to determine the overall performance of the system. The average response time involves taking a series of time reading that is the time it takes the system to detect an object and calculate their total and divide it by the total number of readings. The peak time is taking the highest valued reading which is also considered the worst case response time. The author took 20 readings and observed the time taken by the system to decide the presence of an object.

Table 3 System response times

Test	Reading Time in Seconds
1	3.0
2	0.6
3	2.0
4	0.4
5	0.7
6	0.9
7	2.0
8	0.5
9	0.4
10	1.0
11	0.8
12	0.9
13	1.3
14	1.9
15	1.0
16	2.3
17	1.0
18	0.6
19	0.5
20	0.5

All the readings where rounded to the nearest one decimal place.
Average system response time = sum of all response time/ number of readings
= (0.5+0.6+0.5+0.4+0.7+0.9+1+0.5+0.4+0.6+0.8+0.9+1.3+1.9+2+2.3+1+1)/20
= 17.3/20 =0.865 = 0.8 second (1dp)

The author came to the conclusion of the system having an average response time of 0.8 seconds with the system having an imposed delay of 300 milliseconds. The delay was to enable the author to observe the system. In real time processing the system has an imposed delay of 50 milliseconds.

4.2 Conclusion

The test results indicated the solution had a high level of accuracy since in one scene it produced a 95% rate of accuracy which was a result of the analysis of the confusion matrix. The high levels of accuracy of the system indicate a reduction of false detections in the detecting objects. The provided solution had a calculated average detection time of 0.8 seconds, which is an appreciable response rate. Translating the rate of response, it implies that the provided solution can detect an object on an average time of 0.8 seconds after it has been ignited.

Chapter 5 : RECOMMENDATIONS AND FUTURE WORK

5.1 Introduction

In the previous chapter, the researcher focused on presentation and analysis of obtained data. This chapter covers the research and development of the solution in line with the set objectives. This chapter will also examine the difficulties encountered by the researcher in designing and carrying out this study.

5.2 Aims and Objectives Realization

In summary, the objective of this study was to build a smart ultrasonic stick for visually impaired people and to help the lives of the visually impaired people by building a low cost smart stick. To this end, the researcher developer a system that uses an ultrasonic sensor for object detection. Compared with the controls with average system response times of 4, 5, 1.2 second the produced system had an average response time of about 0.8 seconds with an imposed delay of 400 mili seconds to allow the author to observe the system, the reduction of detection time indicated a capability of the system to detect an object in its infancy and by so doing reducing false detection. The system showed a significance improvement in accuracy with an average accuracy of 95%. The improvement in system accuracy implied a reduction in false detection.

5.3 Conclusion

Using ultrasonic sensor greatly reduced detection time and false alarms as it made decisions based on a major factor considered in object detection that is an object. At a miniature version of object detection the system proved to surpass all the bench marks which were set by the experimental controls.

5.4 Recommendations

There is need for a greater coverage and good sensor positioning to give better and timely reading of the environment around the system to make it more efficient, this is achievable by using better positioned sensors. The author recommends using GPS and vibrator to notify other people and the visually impaired.

5.5 Future Work

The researcher did not have enough time and proper tools that is sensors to carry out the research on a production scale. Future work involves developing and testing the system on a production scale to see if the system and proposals reduce object detection time in a scaled up environment.

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