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Name, Surname: OLUMENSE GOODNESS AGHEDO

Signature:

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To my family…

ACKNOWLEDGMENTS

ABSTRACT

Smart home technology has become popular that majority of homes makes use of this technology to make their homes more easier to control and interact with whenever they are at home from the comfort of a particular position without having to move around the house. Subsequently, there has been an increasing need to create a system that will help visually impaired (blind) person to be able to interact and control appliances within their homes with voice command. This Preliminary system helps to eliminate the need by developing a system using Raspberry Pi to control home appliances with short voice command without the use of internet and give feedback mechanism through speakers to enable the visually impaired person to ascertain if the command carried out was successful using his hearing sense. This preliminary system can help a Visually Impaired person to be more useful within their home in terms of controlling home appliances without the help of anybody and likewise can help future developers develop a more perfect system in the future that will enable the visually impaired to control the homes remotely even when they are not at home.

Keywords: Automation Systems; Raspberry Pi; Smart Home; Visually Impaired; Voice Automation

ÖZET

Akıllı ev teknolojisinin popüler olması nedeni bu teknolojiyi kullanarak evin konforunu ve tadını hissedebilirsiniz. Ev içinde hareket etmeden evin kontrolünü kolayca sağlayabilirsiniz. Daha sonra, ses ile akıllı cihazların kontrol edebilecek şekilde kör insanlara hitap eden bir sistemin yaratılması gerekir. Raspberry pı'yi yaratarak, internetsiz, kısa ses komuta kullanarak ev aletleri ile iletişime geçebilir, hoparlör yolu ile sesin iletildiğini anlayabilir. Bu sistem kör insanların başka kişilerden yardım almalarını azaltarak, kör olmalarına rağmen, kendi başlarına bir takım şeyleri yalnız yapabilmelerini sağlar. İlerde bu sistemi kusursuzlaştırmaya ve kör insanların evde olmadığı zaman içerisinde evin akıllı aletlerine ulaşmalarını sağlamayı hedefler.

Anahtar kelimeler: Akıllı ev; otomasyon sistemi ; ses otomasyonu ; raspberry pı; kör

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LIST OF ABBREVIATIONS

SBC: Single Board Computer

OCR: Optical Character Recognition

VI: Visually Impaired

LCC: Low Cost Computing

GPIO: General Purpose Input Output

DSI: Display Serial Interface

CSI: Camera Serial Interface

GPU: General Processing Unit

RF: Radio Frequency

DPCM: Differential Pulse Code Modulation

APT: Advanced Package Tool

WHO: World health organization

HMM: Hidden Markov's Model

TTS: Test to speech

STT: Speech to test

CHAPTER 1

INTRODUCTION

This chapter highlights the introductory background, statement of the problem for this research, the aim of the study, the importance and limitation of the study and as well the general overview of the study.

1.1 Overview

Mehta et al. (2018), Nowadays smart home automation is a crucial part of our day to day life as it makes life easy for people in generality. Since the early twentieth century, home automation has sized to be a science myth and has become a reality because of the influx of technology inclined appliance into offices and homes. Automation can be achieved in several ways one such is by using Raspberry pi to control appliances. The need for a smart home is increasingly becoming essential part of our daily life because of changes in lifestyles and standard of living (Sen et al., 2015).

Jain et al. (2014) in his defined home automation as the adoption of technology to improve the quality of living in the home via the supply of services that facilitate distance health monitoring, entertainment, and efficient energy usage.

Speech is the most important part of human conversation and very important for effective communication (Aisharya and Sushama., 2016). Their model for speech recognition mechanism was seen when they worked on a project used for controlling a musical system wirelessly using voice recognition aimed at helping old people who cannot move easily and blind people who could not see the musical systems physically.

The current existence of interactive technology infrastructures such as band-width expanded processing ability and connectivity through mobile phones at an affordable cost has led to new concepts related to human living. Smart cities, smart life, and internet of things, etc. are few such trending research fields. A notable concept among these is 'Smart Home', which involves automation and interactive technologies. Being able to recognize and identify others is a key requirement for successful communication (Schelinski et al., 2016). So also, we should be able to communicate and identify with our immediate environment, especially in our homes.

Wang et al. (2017) re-iterated the importance of vocal recognition as a major form of communication and explained how the medium has been used in a pretty long time over the years. It was also stated as the oldest form of communication known to living things.

Chakrabarty et al. (2015) in his research gave reasons why home automation is a key topic in the 21st century making it play a vital role in our daily lives, they also explained how automation is meant to reduce human time, effort and errors due to human error. He demonstrated this with the use of a smartphone and showed how smartphones could help to control appliances around just with voice commands.

The majority of blind people are in the developing world and are over the age of 50 years of age (Ramaswamyy et al., 2018). Hence in their study, they showed how smart gadgets can be used for reading by blind people using the Raspberry pi. In his study he was able to show how image captured in-camera using raspberry pi would be converted to codes using the Optical Character Recognition (OCR) codes and then converted to speech using the Text to speech (TTS) engines of the raspberry pi. World Health Organisation presently puts the number of visually impaired people at 39 million all over the world. So hence the necessity of making life a lot easier for these classes of people to enable them carry out activities and functions without assistance from an external factor. In a research carried out by Gonz´alez-Delgado et al. (2016) showed how wearable support can be enhanced to help visually impaired in face detection, reminder in activities of the day, read emails, detection of objects in their pathways and determining the distance apart, etc. This research was largely successful as it was tested with 5 visually impaired persons and the compatibility/success of the device was rated above 80% of success as these people were tested in various light conditions, environment, and at different time which proved a great success when it was tested in real-time normal conditions. The visually impaired on the hand are not largely considered in the design and construction of these home automation systems (Portet et al., 2013).

1.2 Problem

A number of applications and systems are already in existence to automate homes. These systems help in making homes smart and energy-efficient (Jain et al., 2014), control home appliances, monitor the entire house to ensure safety and security, help to enable visually impaired persons to be able to read normal books (Ramaswamyy et al., 2018). In spite of the existence of these systems, there are some problems associated with their usage. Most of these systems require the internet to function, they perform specified and limited functions and also can be very expensive for an average visually impaired person (Mittal et al., 2015). Most of the systems are not designed with the visually impaired in mind. These systems are usually complex and not easily expandable. Visually impaired persons face difficulty in identifying objects, moving from one place to another, controlling electrical appliances such as fans, air

conditioners, television sets, door locks, radio, etc. Regardless of the fact that there have been lots of tools designed to help people that are visually impaired to gain control of their immediate environment without external assistance from a third party. Therefore there is a necessity to build a system that specifically satisfies the need of visually impaired to be able to control his home and appliances within and to also have a response feedback mechanism that should be able to speak out results of the command carried out by the visually impaired rather than relying on one of their sense organs like their nose, skin, tongue or ear to determine if the command was successful or not. In the glare of this difficulty, there is a need for the development of a feedback response mechanism.

1.3 The Aim of the Study

The purpose of this study is to develop a smart home automation system using Raspberry Pi to control home appliances with a short voice command. Also, give feedback mechanism through speakers to enable the Visually Impaired person to be able to know if the command carried out was successful using his hearing sense.

1.4 Significance of the Study

This system when developed will assist the visually impaired to control and manage their home appliances with short voice command prompts. The order essence of this system is that it can work effectively with or without internet, thereby making it conducive and affordable for everyone. The systems would be able to tell the visually impaired about the state of the appliance and give feedback on the execution of the command to the visually impaired. Regardless of the fact that researches have been done to help visually impaired persons control their home appliances with voice commands, there has been a missing link of creating a feedback mechanism through audio to enable the visually impaired have a confirmation of the command carried out. This research tends to develop a computerized system that helps the visually impaired carry out commands through voice commands and also gives an immediate feedback response to command initiated.

1.5 The Limitations of the Study

During this research, constraints and limitations were eminent due to time constraints, hardware unavailability, and logistics problems.

- The voice command input to the microphone has to be direct.
- Voice command inputs cannot be done from mobile phones.

- This study is limited to us of a USB microphone.
- This study is limited to the Raspberry Pi 3 Model B Vi2.
- This study is limited from September 2018 to January 2020.

1.6 Overview of the Study

This Research consists of 6 chapters, they are Introduction, Related Research, Theoretical Framework, Systems Development, System Implementation and Conclusion.

Chapter 1 gives an entire initiation to Raspberry Pi systems for visually impaired persons, the problem statement, the purpose of the study, the significance of the study, the constraints as well as the general outlook of the entire study.

Chapter 2 talks about similar research on Raspberry Pi for visually impaired persons, where it has been used by previous researchers, their findings and possibly where improvements can be done to improve the lives of the visually impaired.

Chapter 3 is the theoretical framework of the study. This chapter elaborates on detailed explanations of visually impaired persons. It also talks about the Raspberry Pi in detail and how voice command can be used using local mic inputs.

Chapter 4 is the explanation and the detailed description of the architecture of the developed system.

Chapter 5 talks about how the developed system was implemented, with screenshots of most salient stage of the developed system.

Chapter 6 concludes the thesis with results of the implemented system, recommendation, and suggestions for other researchers interested in this field of studies for future advancement

CHAPTER 2
RELATED RESEARCH

This chapter is the related research on Voice automation and Raspberry Pi done by diverse research and successfully implemented to help visually impaired individuals in home automation and also other voice automation researches that might be very important for day to day use. In this chapter, we will be evaluating their findings and also missing gaps in how those researches can be improved. Subsequently the end of this chapter will give a summary and the novelty of this thesis.

2.1 Voice Automation

Haleem (2008) in his study said controlling devices through the human voice is an important application in the implementation of digitalization and automation in this technological era. He also mentions the fact that the development in this area of study has enhanced many types of research in the communication and biomedical engineering fields. His research constituted an investigation into speech recognition and its implantation in manipulating devices and alluded to the fact that it is an alternative of controlling devices instead of controlling with the hand. In his system, after a speech is recognized by a microphone, a MATHLAB code is used to process the speech, the output generates a particular code and transfers this code via a wireless communication system to 8051 microcontrollers. The microcontroller intends to send controlling signals to the control system which controls the devices. In the writer's view, the study was limited by the fact that it was computer-based and therefore it was impossible to implement without a computer. Moreover, the process had to repeat several times to ensure accuracy of voice recognition thereby wasting hard disk space and long processing time. He recommended, Voice controlling automation system to use in controlling Distributed Control System. And recommended a faster process to achieve this automation.

Funk et al. (2008) in his research was able to build a system used for controlling home automation through voice inputs. These voice inputs were done through a telephone unit that receives voice command and then sends a signal of the voice input to the voice portal server which then converts the voice input signals to a set of commands used for controlling the home automation system based on the integrated voice inputs. The home interface usually controls the home device based on the command it receives. This research was able to show and prove that it is possible to remotely control home devices through voice inputs with the use of a telephone.

Alshu'elli et al. (2011) carried out a voice recognition command test using low-power RF (radio frequency) ZigBee wireless communication modules which are considerably affordable. The research concentrated on voice acknowledgement, feedback test, indoor ZigBee interaction test, and compression and decompression test of DPCM speech signals. The research comprised of a combination 35 male and female subjects with diverse English accents. 35 unique voice instruction was sent by each person; thus, a total of 1225 command was sent and 79.8% of the total voice command was recognized and interpreted correctly.

Mittal et al. (2015) in his research aimed at using voice speech which would be recognized by Raspberry Pi to control home appliances. This project was seen to be cost-effective as it cost less to get the necessary device used for the project. Mehta et al. (2018) in their study showed the practical illustration of how to use Raspberry Pi, sensor and Android system to control home appliances. This project was basically into two parts, where the first part was simply using the android system to give control to the device that one wishes to control locally or remotely while the second part of the project simply highlighted how the Raspberry Pi is connected to all the sensors and devices in the home automation system to be controlled remotely. This study was able to gain success in reducing the power consumption by home devices and also was able to reduce human power in controlling the devices.

Sonali et al. (2015) developed a voice-powered controller with the aid of an android smartphone which is connected to a system (control circuit). The developed system consisted of an Arduino Uno microcontroller that carries out the user command and commands the switching of the devices. The voice command input is received by the android smartphone which in turn transmits the data to the Arduino Uno microcontroller through Bluetooth for processing of the command and carrying out the specified instruction.

2.2 Raspberry Pi Monitoring System

Nguyen et al. (2015) carried out a research on Closed Circuit Television (CCTV) surveillance system using Raspberry Pi in other to effect peace and supply security to people at an affordable rate for all. In their research, the Raspberry Pi uses the motion discernment algorithm technology written in a python programming language to capture real-time videos that can be viewed from any web browser and also even from mobile phones as they happen. The system takes advantage of the motion detection algorithm to largely reduce storage usage and save investment cost by enabling live streaming cameras along with noticing of motion.

Agrawal and Singhal (2015) also proposed a smart drip for irrigation with assistance of Raspberry Pi and Arduino. They additionally proposed a home automation system where Raspberry Pi was used as the brain box of the system coordinating processes between the end devises. ZigBee was used as the backbone of exchange of data between devices in their proposed system. Raspberry pi was used to process commands from the user in conjunction with python. The Arduino received instructions form the Raspberry Pi to control the relays. In their proposed system emails could be sent to the system to irrigate both farms and gardens. In the writers' view, the system was easily scalable because of the use of Raspberry Pi.

Rohan et al. (2016) developed a Raspberry Pi controlled traffic density monitoring system. This system was developed to assist travellers to determine the traffic condition of any particular area they intend to travel through. This device was able to be used for traffic surveillance where the traffic is continuously monitored, recorded and used to give traffic reports to travellers through a digital screen publicly for travellers to see. It was concluded that this project was able to automate the traffic density monitoring system which would help travellers get first-hand information of traffic condition on their route of travel, it also helped in avoiding usage of papers and plastics for advertising, it also showed the immense boost this project will give to the environment by reducing plastic usage and deforestation, and of course its cost-effectiveness.

Lakshmi et al. (2017) showed the possibility of having smart image monitoring where people can be their own security and at the same time control their door lock remotely from anywhere using mobile technology. This research was carried out using Raspberry Pi, Mobile devices, webcams, and sensors. The logic was simply using the webcams to capture real-time images of whatever that was going on in the specified areas which were connected to the Raspberry Pi and the sensors which transmitted information wirelessly to the mobile device. This research was able to show the importance of home automation in providing essential security for our homes and for remotely controlling devices in our homes using mobile technology. It also enables users to constantly follow the security status of their homes from anywhere. It reduces the cost of securing the home.

Kyaw et al. (2018) in their studies mentioned the need and efficiency of the use of Raspberry Pi to enhance computer science study in developing countries. The researchers made a literature review on the usage of Raspberry Pi in a low-cost computing (LCC) project. They experimented LCC environment setup, which used a Raspberry Pi 2B as well conducting cost-benefit analyses to ascertain where their proposed LCC system was feasible to be implemented

in schools of poor countries. The researchers found out in their relative study on raspberry pi that, Raspberry Pi was greatly utilized in different lost cost but effective computing projects. Their contribution to literature on Raspberry Pi was to use and exhibit the use of Raspberry Pi 2B in a client computer internet based LCC system. In their system they used a number of Raspberry Pi, physical servers, cisco catalyst switch in addition to virtual servers to create VLANS to implement LCC for both classroom and library. In their study, they found out that LCC environment could be used in a classroom and a library in poor counties because of its cost and efficiency.

2.3 Smart Home Automation

Aldrich (2003) in his study described "smart home" as a house that furnished with computerized and technological systems. These systems are to foster judicious usage and management of energy, comfortability as well as entertainments but not compromising the security of the house. This is achieved by the system waiting for instructions from the sensors or the occupants of the house to be executed to satisfy the need the occupants of the house with the home and outside the home.

Gill et al. (2009) carried an experiment with automating a home with ZigBee together with a Wi-Fi network. They made mention of the fact the expansion of the ubiquitous internet has brought the need of having to control and monitoring the home remotely. In their research, they attempted to address issues preventing the full-scale home automation implementation with their flexible home automation system. In their proposed system, they used a ZigBee, Wi-Fi tighter with a gateway to control a few home appliances. Users can connect, monitor and control the systems via the internet remotely or with a remote control while they are home. Devices and a database are connected to a ZigBee coordinator to control them. A home gateway grants access remotely and locally to the untie system for manipulation. They also created a virtual home to ensure security of the system from unauthorized users. In their view, their stand-alone system was a cost-efficient way of using Zigbee to automate home. And their system was simple and scalable and allowed a variety of commands for different sources.

Baraka et al. (2013) in their research described a smart home as a home designed in such a way that appliances in the building are controlled remotely for comfort and efficient use of energy. In their research, they made mention of a sensor installed at the entrance of such building and at the detection of the presence or the absence of a user, the sensor automates the appliances to ensure efficient usage of energy and to for the comfort of the user.

Park and Lee (2017) also in their project designed a system to remotely monitor the safety of infants in their rooms. The researchers project generally monitors the position, temperature in the infants' room and the activities carried out by the infants in their rooms. The system periodically alerts parents and caretaker's phones in regards to the wellbeing of the child via Bluetooth. Caretakers and parents of the other hand can see, monitor as well as control temperature and illumination in the child's room. It can send periodic alerts and nightly reports to a smartphone by using ultra-low-power Bluetooth connection. Caretakers can monitor live happenings of events as they occur. It can also be connected to oter devices through special connectors, for example, if the baby temperature is nt normal a smart thermostat can alter the room temperature, or if the baby is moving a webcam can be turned on to physically keep an eye on the baby.

Majumder et al. (2017) also in their research made mention of a smart home been an integration of actuators, sensors that are worn by patients and modern technology which ensures ubiquitous monitoring of the wellbeing patients or the physically challenged at a very affordable price. In the researcher's view, the idea of smart homes enables the patients to stay in the comfort of their homes and still be monitored by healthcare personals as an alternative to been inexpensive hospital environments.

Other researchers have also developed various forms of a smart home for different purposes all in the bid of making life comfortable and assisting it uses energy. Green (2019) developed a smart home in which the system enables the user to control gadgets in the house from a distance as well as keeping a track of the energy consumption in the house with the help of a sensor. Pflanzner and Kertész (2018) in their studies developed an electrical system smart in nature to control appliances remotely with the help of his smartphone which is used to set time to turn the appliance on or off.

2.4 Summary of the Related Research

The literature reviewed shown there is a number of systems that utilizes the microcontrollers together with other systems implement home automation system. But nor they were specifically developed for the visually impaired and not gives audible feedback of the state of the appliances or the action taken.

CHAPTER 3
THEORETICAL FRAMEWORK

This chapter explains home automation, voice-prompted automation, smart homes, python and Raspberry Pi with examples of projects that implemented and used those technologies.

3.1 Overview of the Smart Home Automation Systems

Z-wave (2018) tried to differentiate "Smart home" and "home automation". Home automation is among one of the numerous things a smart home can perform. A smart home, on the other hand, is a network of devices, sensors using any appropriate networking technology such as Bluetooth or Wi-fi to exchange data between these devices and other devices to control as well as regulate the actives of appliances. A smart home may include security camera that can be monitored remotely, programmable thermostats of temperature controlling device. These thermostats are instructed by a pre-programed schedule or by mobile phone. In smart homes, energy consumptions can be monitored and tracked in real-time as well.

3.1.1 Smart home

There are assorted definitions of what a smart home is according to the views of different researchers on various aspects of smart home automation. Gómez-Romero et.al. (2018) explained a smart home as a home that integrates cutting- edge automation of appliance enabling the residents to be able to have advanced monitoring and controlling abilities. The writers made mention of some appliances that could be monitored and controlled in the home by the smart home system, these include windows and doors, cameras for security purposes, as well heating and cooling systems in the home among others.

Devereaux (2018) similarly defined smart home as a home furnished with a computer-based technological system, which has enhanced the inhabitant's comfort. The researcher further explained that a Smart Home is designed to respond to the needs of the occupants of the home.

The United Kingdom Department of Trade and Industry (DTI) describes a "smart home" as a dwelling [home] incorporating a communication network that connects the key electrical appliances and services, and permits them to be remotely controlled, monitored or accessed". Figure 3.1 is a pictorial description of how a home can be made smart.

Figure 3.1: Smart home

3.1.2 Advantages and disadvantages of smart home

A Smart Home has a number of merits and demerits. Some of the disadvantages of a Smart Home are that it is in some cases expensive to implement. Also, fast internet accessibility is required. Setting up and configuring a smart home is sometimes difficult and cumbersome to undertake. One of the major difficulty with a Smart Home is its security threats, there is usually a high possibility of unauthorized persons getting access to the centralized system of a home. There are also issues with the amalgamation of different protocols for transmission and communication between various parts of a smart home system.

There are however numerous advantages that come with home automation systems, some of which are: It helps in energy conservation. Smart homes are energy efficient because the system is able to sense the presence and the preferred level of comforts such as temperature and conserve the electrical energy when it is not needed. Another advantage that comes with smart homes is that it enhances security in a home by enabling the user to monitor the home from anywhere. The smart home also allows a home to be customized to suit the habitant's comfort and style. Time is saved by habitants in a home when it comes to undertaking repeated routines in the home. Last but not least, in smart home, activities in the home is carried out without human interruption and time.

3.2 Smart Home Technology

Generally, smart home technology is a terminology given to home appliances fitted with communication, innovation and empowered with some level of computerization, automation or remote control. Smart home technology includes the following:

3.2.1 Programming language

Programming laguages are generally used in the configuration of devices used in a home to make it smater. There are several programming languages used for programming but for this purpose we would be looking into the use of Python Programming Language

3.2.1.1 Python

Python since its first release in 1991 by Guido Van as a general-purpose programming language (Perkel, 2015). It has been wildly used and a preferred programming language because of its code readability simple syntax, indentation and white spacing (Virtanen et al.,2019). It is an interpreted programming language that executes instruction directly and freely without having to be compiled. It is a vital programming language used for both small and big projects. It is a very efficient memory management language that is object-oriented as well as procedural (Lourenço et al., 2019).

It is used in developing Graphical User Interfaces, websites as well as other web application programs. It has a number of advantages over other programming languages, some of which are its easy readability and therefore can be maintained as well as update easily. It supports a variety of programming paradigms and it as well supports multiple platforms. It has an enormous, easy to use and readily standardized library to assist users to undertake complex projects easily. Despite is usefulness it is open source and is very useful for both prototype software development and actual software implementation. Python has many advantages as aforementioned, conversely, like other programming languages, it has its own inadequacies. It does not have some inherent features that other present-day programming languages have. Consequently, there is a need to utilize Python libraries, modules, and structures to quicken custom programming to the advancement of the user. Additionally, a few examinations have demonstrated that Python is slower than a few broadly utilized programming languages such as Java and C++. Some settings will have to alter in other to accelerate Python application by making changes to the source code for customization

3.2.1.2 Internet of Things

It is widely spread that Kevin Ashton in 1999 initially used the term internet of things to describe a system in which sensors and devises are connected to the internet ubiquitously (Atzori al et., 2017). He farther explained that computers, the internet, and the environment depend on humans for information

Tidd and Bessant (2018) also explain the internet of things as an increasing technology because daily, new Devices and Sensors are connected to the internet to facilitate and make homes, offices and our environment smarter. These in the researcher's view, these go a long way to improve services, security, energy consumption and facilitating comfort of inhabitants of a home. Raja and Mandour (2019) also made mention of how the invention of Smart Home Automation System (SHAS) has resolved a number of problems in our environments and homes in recent times. Silva et al. (2018) also think smart home is of the main aspects of Internet of Things, which comprises appliances and sensors interconnected in a network with the help of software to make a home smarter and comfortable. Figure 3.2 explains how sensors and devises are interconnected with help of the internet forming Internet of Things

Figure 3.2: A figure of Internet of Things

3.3 Automation of Smart Homes

Home automation constitutes a system that automates electrical and electronic gadgets with the controlling emanating from a technology. The system usually amalgamates software and hardware components to ensure the automation.

3.4 Ways of Utilizing Smart Homes

There are numerous ways and reasons for utilizing Smart Home technology. Below are a few of them:

3.4.1 Energy efficiency

Smart Home can be implemented in divers innovative ways to ensure safety and comfort to the users in the building. Djenouri et al. (2019) in their study utilized home automation to remotely control appliances and efficiently use energy. In their developed system, a network of an android application, user interface sensors and actuators are used to communicate to automate the house with Arduino being the central processor. Zigbee together with X10 technologies was used as the communication medium for the entire network. This, in his view, made the system considerably economical.

3.4.2 Protection of smart homes

Carleson (1973) in his research developed a system to protect a home with the use of a tape of a barking dog. In the developed system, a periodic alarm of barking is activated by an install timer as well as the alarm can be triggered by the detection of motion with the help of a sensor. This automated barking dog in the writer's view helps to beef up security in the house

Chowdhry, Paranjape, and Laforge (2015) in their study developed a home automated security system in which unauthorized entry into the house is detected with the aid of Histogram of Oriented Gradients as well as Support Vector Machine. These in the researcher's opinion helps owners of the house to decipher alarms raised by security dogs. In the developed system, the status of appliances in the house is known remotely because they are networked with a centralized computer system.

Anitha (2017) also developed an affordable Internet of Things based home security system for both domestic and industrial use. Arduino Uno was used as the central processor to send a notification to the state of the door and unauthorized enter is sent to the owner of the house. ESP8266 was used as communication medium for the sensors and buzzers via the internet.

3.4.3 Health care

Pflanzner et al. (2017) developed a smart home that assists people with clinical conditions. The system reminded the patient to take their medication punctually with the help of a blue tooth connected linking the users' mobile phone and the bottle top. Flashes of light on the bottle top, text messages and ultimately a phone call are used to alert the user when the time is due for taking their medication. The pharmacy close to the user can also be connected to the system to make easy the process of punctual medication. Truong et al. (2009) also used a home automation system to abet dependent patients or the aged. In their developed system, doors, windows, and home appliances are controlled and observed based on the activities of the occupant of the house. Data collected from these controlling sensors are inputted in an online system in which an algorithm is used to replicate the control of appliances in the house to ease the life of the aged and or the occupant of the house.

3.4.4 Comfortability

Al-Kuwari (2018) in his research developed a home automation system to perpetuate comfort in the home in such a manner by monitoring and sensing of parameters of appliances in other for them to be controlled remotely. In his developed system temperature, humidity, audiovisual, as well as other comforts in the home, are attained through the monitoring of related parameters with sensors. When data from the sensor are fed into his system appliances are automated to ensure both comfort and judicious energy usage in the house with the help of IoT.

3.4.5 Environmental monitoring

Selvaraj et al. (2018) proposed a smart home IoT based system to monitor and control appliances in a house via the internet. The researchers used a raspberry pi in conjunction with Zigbee technology, smartphone, and cameras to monitor the house. In their research, the developed system is able to know the state of the appliance and control it via the internet. With the help of connected relays, the user is able to control the individual appliance by the raspberry pi.

3.5 Voice Prompted Smart Home

Voice prompt, which in some article is referred to as Speech Recognition is a system in which a computer system makes use of both software and hardware to recognize the human voice in other to control the system. Voice recognition is usually used to perform functions that would have been executed by input devices like keyboards and mouse.

Zhu et al. (2010) in their research developed and implemented a speech recognition system that utilizes ZigBee to automate a home. In their research, a number of speech recognition modules are used to detect and recognized a voice command used voice modules in conjunction with ZigBee based networks. These detected controlling speeches are sent to the targeted devices by these modules and the instructions are executed by circuits supposed to execute the instructions. Their developed system needed no training to recognize speech because an SI-ASR (Speaker-Independent Automatic Speech Recognition was implemented to ensure the process of voice recognition. In the writers' view, the system was secured and was a helpful way to automate a home for especially the aged as was the people living with disability.

3.6 Raspberry Technology

There is various single-board computer (SBC) but the raspberry foundation has made tremendous impact on the SBC market because of its flexibility, affordability, and availability. Although the Raspberry Pi was initially intended for the improvement of teaching computer science, it is currently utilized in assorted projects: engineering, logistics sector, art exhibition, and medical sector just to mention a few. It supports a diverse array of Operating Systems including Windows, Linux, BSD, Risc OS and Debian (Cox and Johnston, 2018).

Raspberry Pi was first released in February 2012, Raspberry Pi Model B first generation. The Raspberry Pi had received massive patronage because of its low cost and performance. An added advantage it has is that by adding a couple of peripherals the Raspberry Pi functions as a complete functioning computer with Raspbian, a Debian-based Linux as its Operating System. It is usually described as a Single Board Computer (SBC), implying that it can function as a full operating system and adequate peripherals to execute instructions. Some versions of the Raspberry Pi are network bootable if it has a file storage system such as a micro SD card (Vogiatzaki and Krukowski, 2014).

Perna et al. (2018) described Raspberry Pi is a powerful SBC with 8.56 cm – 5.398 cm – 1.7 cm as it dimensions which makes it a suitable device to fit into an electrical junction box for home automation systems. Daryanavard and Harifi (2018) in their research made mention of the fact that although very powerful with a processor constructed on SoC chips known as BCM2851, Raspberry pi is very affordable with its price ranging between 5$ to 35$ with respect to the model. The Raspberry Pi with its functions as a personal computer needs a power supply, display unit and some basic input devices such as keyboard and mouse. However, it may not need display unit, mouse and keyboard when used as a Web server. When used a web

server, the Raspberry Pi connects with a number of single-purpose devices such as sensors to form a network. It functions as a fully functional computer and therefore connects to other peripheral devices to accomplish as purposes. It is used in the design and construction of systems such as home automation systems, arcade machines, games, security systems. Additionally, it used in the robotic field, hobby projects, server/cloud server, print server, security monitoring, web camera, wireless access point internet radio, temperature tracking and other interesting automation systems that require no human interventions to operate (Zouai et al., 2019).

3.6.1 Power supply

Raspberry Pi can be powered up with a number of different power sources that produce an output current of 700mA. (Vujović and Maksimović, 2015). Among the devices capable of powering raspberry pi up are PC USB port, mobile phone charger, and backup batteries. Sometimes, the amalgamation of energy from AA alkaline batteries can be used to power the raspberry up so long they are capable of generating the requisite current.

3.6.2 Power modes

There are four power modes of the raspberry pi and the states of the processor and the memory of the raspberry pi in these four moods are explained in Table 3.1 below (Goodwin, 2013).

Table 3.1: Power modes of Raspberry Pi (Raspberry Pi, 2018)

Power mode	CPU	ARM11
The run mode	All functions accessible	All functions accessible
The standby mode	Not all functions are accessible (the clock)	Interrupt signal can be executed
The shutdown mode	All functions are not accessible	All functions are not accessible
The dormant mode	The core is shut down	Caches are powered up

3.6.3 Operation system

Raspberry Pi can run on a number of Operating Systems. However, Raspbian is one of the dominant operating systems, it runs in a Debian-based Linux based Operating System. Raspberry pi has preinstalled ready to use software such as python, java, and scratch. The operating system has both a command-line interface and a graphical user interface (Aqel et al., 2018). Other third-party Operating Systems such as Ubuntu Mate, Windows 10 IOT core, weather Station, ICHIGO JAM RPI, and Snappy Ubuntu core just to mention a few are executable on Raspberry Pi.

3.6.4 Models of Raspberry Pi

Raspberry pi is classified into three models, namely Pi Zero, model A and model B. These individual models further have assorted products. Table 3.2 describes the models and products (Core – electronics, 2016).

Table 3.2: Models of Raspberry Pi (Syafrudin et al., 2019)

Model	Products	Release Date
Raspberry Pi A	Raspberry Pi 1 Model A	2013
	Raspberry Pi 1 Model A+ revision 1.1	2014
Raspberry Pi B	Raspberry Pi 1 Model B revision 1.2	2012
	Raspberry Pi 1 Model B+ revision 1.2	2014
	Raspberry Pi 2	2015
	Raspberry Pi 3	2016
Raspberry Pi Zero	Raspberry Pi Zero	2015
	Raspberry Pi Zero W	2015
	Raspberry Pi Zero WH	2016

3.6.5 Features of Raspberry Pi

Raspberry Pi has Broadcom BCM2837 64-bit Quad-Core Processor as its microprocessor and runs on 3.3Volts as its processor operating voltage. It operates on 5Volts, 2Amps from any power source capable of providing that voltage. It has a Flash Memory 16Gbytes SSD memory card usually used to store the Operating System. Raspberry Pi has a fast-Internal RAM of

1Gbytes DDR2 which makes it a fast option among another SBC. It also has clock frequency 1.2GHz the Raspberry Pi contains a Graphics Processing Unit(GPU) which **is** Dual Core Video Core IV Multimedia Co-Processor which provides Open GLES 2.0, hardware-accelerated Open VG, and 1080p30 H.264 high- profile decode. This make is able to display 1G pixel/s, 1.5G Texel/s or 24G FLOP/s with texture filtering and DMA infrastructure. With regards to connectivity, the Raspberry Pi makes use of 1/10 Ethernet, BCM43143 (802.11 b/g/n Wireless LAN) for wireless connectivity. It also has installed 4.1 Bluetooth technology which in some cases can be utilized for connectivity. For input-output, it has four 2.0 USB sockets, a 3.5mm Jack for audio and HDMI for video display. The device has an on-board 15-pin MIPI Camera Serial Interface (CSI-2) that can be used to connect camera as well as a Display Serial Interface (DSI). 15-way flat flex cable connector with two data lanes and a clock lane for display connector. Figure 3.3 is pictorial explanation of the features of the raspberry pi.
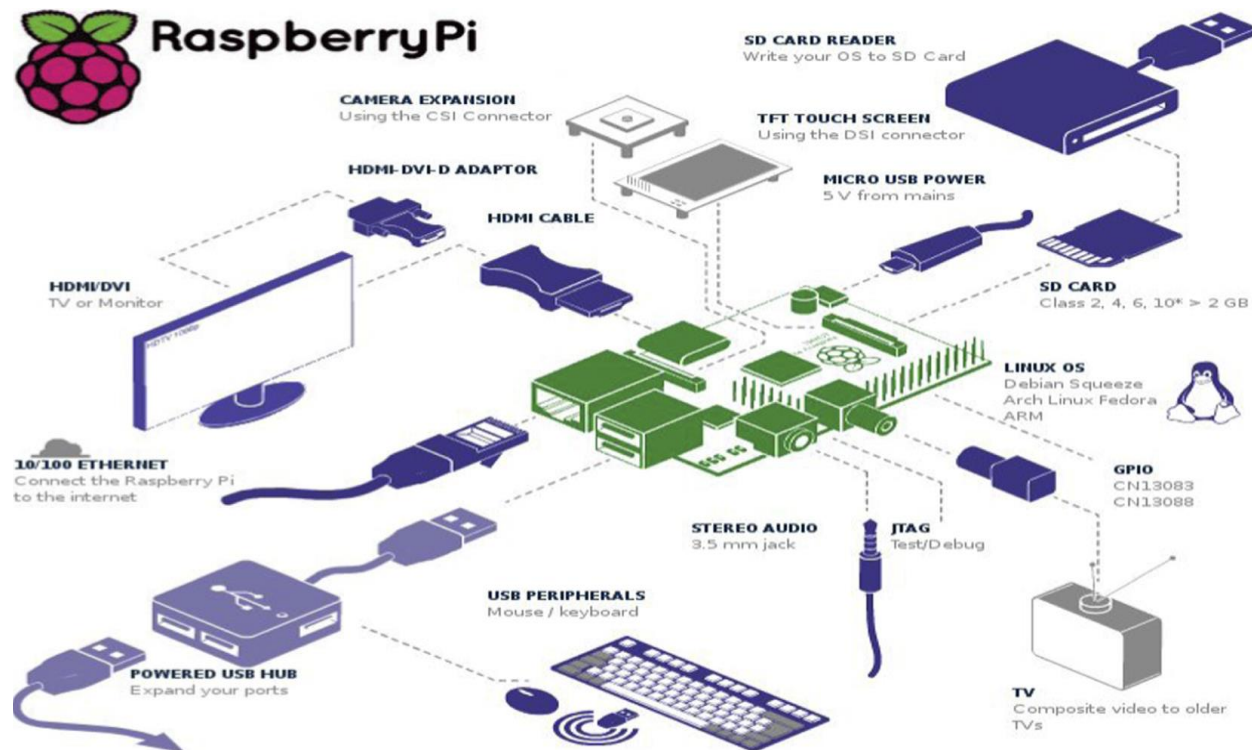
Figure 3.3: The components and features of Raspberry Pi (Raspberry Pi, 2018)

3.7 Speech Recognition

At the point when people talk, it prompts the production of vibrations in the air. These vibrations result in speech. To change over a speech to text, a number of few complicated steps and processed a computer.

The capacity of a machine, computer or a program to distinguish the words communicated among humans in a language and convert them into text is known as Speech Recognition. The convertion of Speech to text popularly known as Automatic Speech Recognition in itself is a sub-disciplinary field in computer phonetics. It is sometimes abbreviated as STT. The process of speech recognition begins with a creation of vectors extracted from acoustic speech vectors spoken by humans throught a transmission channel. A filtration process then takes place to eliminate unwanted signals that come in the form of noise and undesirable frequencies are separated from the desirable ones. The separated signals are then further normalized and adjusted to ensure a consistent volume for further detailed segmentation of the signals. These synthesized audio signals are then forwarded to a server or a library and decoded Hidden Markov Model, grammars and then dictionaries. The wave are further translate into text using Natural Language Processor and Database Processor, it is then optimized by SQL (Structured Query Language). A database is searched and the matching words are typed out on any platform. Figure 3.4 describes the process of speech to text convertion.
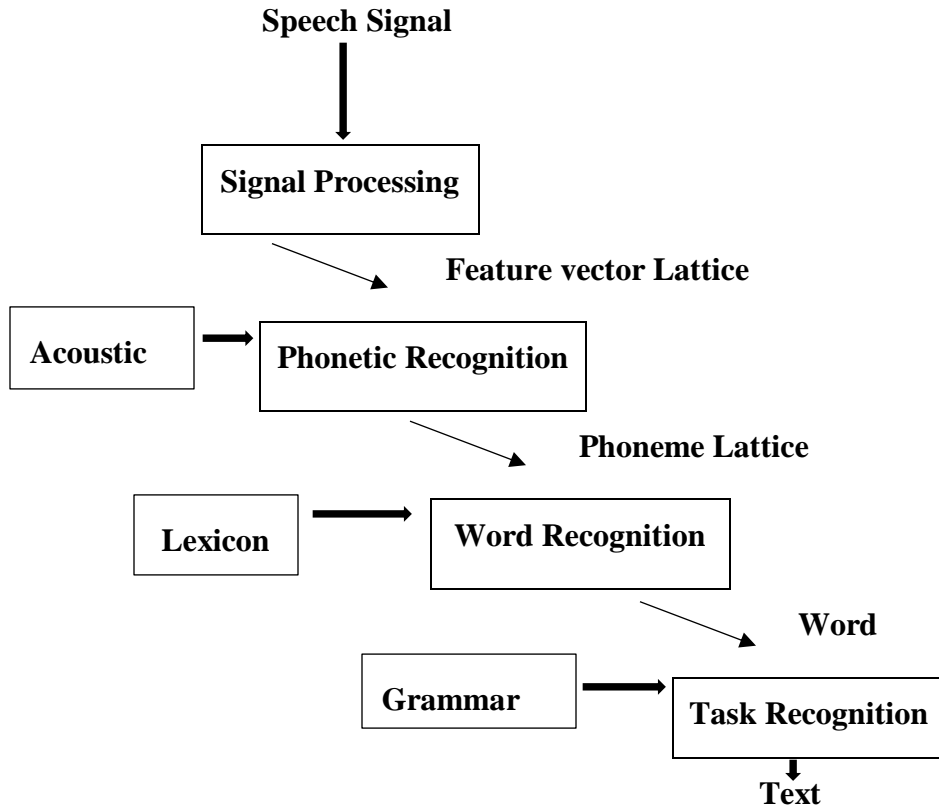
Figure (Speech Recognition HMM model)

```
                    Speech Signal
                          │
                          ▼
                 ┌──────────────────┐
                 │ Signal Processing │
                 └──────────────────┘
                          │
                          ▼     Feature vector Lattice
 ┌──────────┐    ┌──────────────────────┐
 │ Acoustic │──▶ │ Phonetic Recognition │
 └──────────┘    └──────────────────────┘
                          │
                          ▼     Phoneme Lattice
 ┌──────────┐    ┌──────────────────┐
 │ Lexicon  │──▶ │ Word Recognition │
 └──────────┘    └──────────────────┘
                          │
                          ▼     Word
 ┌──────────┐    ┌──────────────────┐
 │ Grammar  │──▶ │ Task Recognition │
 └──────────┘    └──────────────────┘
                          │
                          ▼
                        Text
```

Figure 3.4: Speech Recognition HMM model of the developed system

3.7.1 Challenges with speech recognition systems

It is however, worth mentioning that, there are a number of challenges with speech recognition, these are as follows.

There is a challenge for the system to work well in a noisy environment, and the speech recognition system requires intensive use of computer power. There are issues with people speaking a different accent, and it is difficult for the system to detect speech when the speed of the speech is fast. Speech recognition systems encounter problems with punctuation marks as well as homophones

3.8 Disabled People

15% of the world's population have tendencies of a form of disability (W.H.O). This statistic is more prevalence in developing countries. Disability is a global menace and hence the necessity to help people living with this disability to have a much more simple and comfortable life.

Disability among humans come in different forms. Nepal disability as individuals who are rationally or physically unfit to have a normal daily existence. Essentially, the World Health Organization's (WHO) defines of disability as signifies hindrances, action confinements and limitation of involvement in activities. The term incorporates people who have hearing and visual disabilities. It also includes people of the inabilities to move from one place to the other easily.

Disability problem is a global phenomenon and a burden for both individual persons and society. (Zheng et al., 2014). According to the China Disabled Person's Federation(CDPF), physical disability is expressed as a loss of motor control of varying degrees or limitation in movements or activities as a result of deformed limbs or body paralysis caused by damage to the structure or role of those body parts involved in mobility (Zheng et al., 2014). There were approximately 85.02million people living with disability in China, and physical disability constituted the largest sub-group, at 29.07% (China Disabled Person's Federation, 2012).

3.8.1 Types of disabilities

There are different types of disability, some of them are listed below:

- *Physical disability*: is a hinderance on a person's physical functioning, mobility, dexterity or stamina. Other physical disabilities include impairments which limit other facets of daily living, such as respiratory disorders, blindness, epilepsy and sleep disorders.
- *Vision-related disability*: This is a disability where an individual can not make use of his eye sight for. This disability is usually not fixable and can not be corrected as a result of the critical damage already done.
- *Hearing-related disability*: This is a condition where a person has partial or total loss of hearing with their ear. A partial or full hearing disability is also seen as a disability.
- *Deaf-Blind*: An person who has both vision disabilty and hearing-related disability.In this case he/she is deaf-blind.

- *Voice and speech-related disability*: This is defined as a communication dis-order such as stuttering, impaired articulation or even a voice impairment and this in a great way affect child learning..

- *Mental Disability*: This is a major form of disability, which when treated can lead to a severe emotional, physical or behavioral problems. Below is three forms of mental disability:

- Where a person cannot perform activities that is expected of them to perform or environment as a result of no mental growth prior to the age of 18 years, they can be described as being intellectually disabled or mental retardation.

- Where a person cannot perform his normal daily routine as a result of Mental illness, these persons can be said to have chronic mental illness.

- Where a person to behave normally and unable to communicate as a normal human as compared to their age or where they constantly repeat a particular activity, they are said to have autism.

- *Multiple disabilities:* when a person exhibits more than one type of a mental disability.

3.8.2 Difficulties encountered by visually Impaired

Whereas disable persons go through a number for daily challenges, the blind, on the other hand, encounters a number of specific challenges unique to them. Most of the challenges physically abled people think are problem to them may not necessarily be and the vice versa. Some of these challenges are :

- *Navigation:* Blind usually have challenges in moving around places they are not familiar with. Especially those that have totally lost their vision, they are let at the mercies to others, facilities and in some cases pets to navigates their ways around places they are not familiar with.

- *Reading materials:* Braille is the mode in which blind persons read written text, but unfortunately, most textbooks are not written in this formats for the blind to be able to access the content of these books. Most web sites are to designed to enable the blind to easily assess the content of those sites.

- *Clothes arrangement:* The visually impaired usually rely on touch to identify and arrange things. Though most of them try to find ways and means to arrange and sort out their

clothes, when it comes to arranging textiles and cloths, they encounter challenges with sorting pairs of socks, cloths of different colors and things that are difficult to sort by touch (Sekyere-Asiedu, 2018).

- *Independence:* Gaining independence is one of the most treasured things for a disabled person. A visually impaired person can lead an independent lifestyle with some in particular designed adaptive gadgets to help them. There are quite a number of theses adaptive equipment that can allow a blind person to stay independently but they are scarce and expensive.

CHAPTER 4

METHODOLOGY

This chapter talks about the methodology used in developing the system as well as the software development life cycle used in developing the project. The system consists of a software part and the hardware part. This chapter seeks to explain the various component involved in the development as well as the python libraries used.

4.1 Software Development Life Cycle

The methodology used in the developed project was a software development methodology know as Waterfall Model. The stages in the development also known as Software Development Life Cycle is a sequence of activities carried out doing the development and testing software. There are V-Shaped, Iterative, Spiral and Agile Models all of which are some of SDLC models used in developing software and projects. In this project the waterfall was used because of the following reasons:

- This model pays attention to departmentalization and administrative control.
- Uncomplicated as well as uncomplicated.
- This model can be easily supervised because of the unbending nature of the model. Each phase has clear anticipation and an audit procedure.
- Each step is are executed and completed in turns.
- It is good to be used for small projects where prerequisites are very surely known.
- Itinerary can be set with cut-off times for each phase of advancement as well as an item can proceeded through the entire project.

Although the waterfall has its advantages, it also has a number of disadvantages, these are:

It is difficult to take into consideration many reconsiderations or amendments.

- Once a developed system is in its final phase, it is almost impossible return and change aspects of the previous stage.
- No developed system is delivered before the end if the SDLC.
- High measures of hazard and vulnerability.

- Poor model for long as well as continuous tasks.
- Not appropriate when developing projects that has its prerequisites are at high likelihood of metamorphosing.

The waterfall models are usually utilized for the following reasons and under circumstances such as these. This model was in as well implemented for the same reasons.

- Requirements are well defined and fixed.
- The product definition is constant.
- Technology is grasped.
- Ample assets with required mastery are accessible uninhibitedly
- The undertaking is brief.

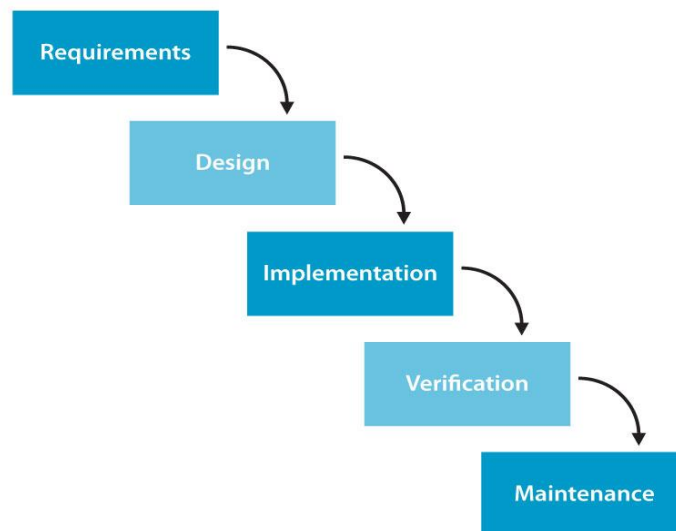Figure 4.1 is a pictorial explanation of the water fall model.

Figure 4.1 Waterfall model

All the stages in this project was developed base on the waterfall method and were grouped by type of activity and each project as follows:

4.1.1 Project planning

This stage entails all discussions to which all the the stages of the waterfall model is carried out. It is usually carried out by the whole team involved in the design of the project.

4.1.2 Requirements definition

The author of the project together with his supervisor defined the requirements of the project and come out with the following requirement to help the visually impaired at home:

The requirement was to develop a system using Raspberry Pi to control home appliances with a short voice command without the use of the internet. Also, give feedback mechanism through speakers to enable the visually impaired to be able to know if the command carried out was successful using his hearing sense. A python script was to run the raspberry pi to control relays, which will intend control the appliances.

4.1.3 Design

The following technologies and devices were chosen. Circuit diagram for the developed system was also designed

- The voice command input to the microphone has.
- A USB microphone.
- Raspberry Pi 3 Model B Vi2.
- Four in one relay.
- Breadboards
- Jumper cables
- Servo motors
- LED light
- fan

A python script which is attached in the appendix was also planned and based on the flow chart and the use case diagram, which are also both in the subsequent chapters of the thesis.

4.1.4 Development

For the development of this preliminary study, the use of python codes was instrumental throughout the research and it proved to be the most suitable programming language to implore.

- *Coding*: Python Programming Language was used for every process of programming in this preliminary study as shown in the APPENDIX 1 of this paper.
- *Speech Recognition:* Speech recognition is the ability of an electronic device to understand and interpret spoken words (Cavus et al., 2018). This entails a microphone recording a person's voice and the hardware converts the signals from analogue sound waves to digital audio, which therefore is channelled into the speech recognition system for interpretation that the system will understand. Also Speech recognition has a very long history of being one of the difficult problems in artificial intelligence and computer science (Reddy et al., 1990). Hidden Markov's Model (HMM) of speech recognition was one of the first models of speech recognition that was developed to solve the problem of speech recognition. HMM are a short representation of speech events that uses machine-learning algorithm for voice detection, therefore they require less storage than many other strategies. The forward-backward re-estimation algorithm for Hidden Markov's Model was used during the speech recognition process for this Primitive system to help with the conversion of speech to text (STT) and text to speech (TTS) part of this system.

4.1.5 Integration and testing

The various parts of the system were constructed and connected as in the circuit diagram. Jumper cables were used to attain this connection to connect the raspberry pi and to the breadboard. Then the relays were connected to the devices with the help of jumper cables. The codes were run on the raspberry pi and the tested step by step

- First, the function that converts audio voice to text is examined to ensure that it is working properly.
- The function of the code that turns the GPIO pins that opens and controls the relay was subsequently tested and debugged.
- The audible part of the output was also further tested. The entire code and system were tested and corrected to suit the planned output and results expected.

4.1.6 Maintenance

The system was further tested by other experts and their contributions were added to make the system behave as specified in the requirements in the plan

4.2 System Architecture

There two main constituents of the developed system are hardware and software. The hardware are made up of the Raspberry Pi 3, a relay board, door, window, light, air-condition and a fan. And the software parts constitute python codes as well as libraries. Figure 4.1 is a block diagram describing the architecture the developed system.
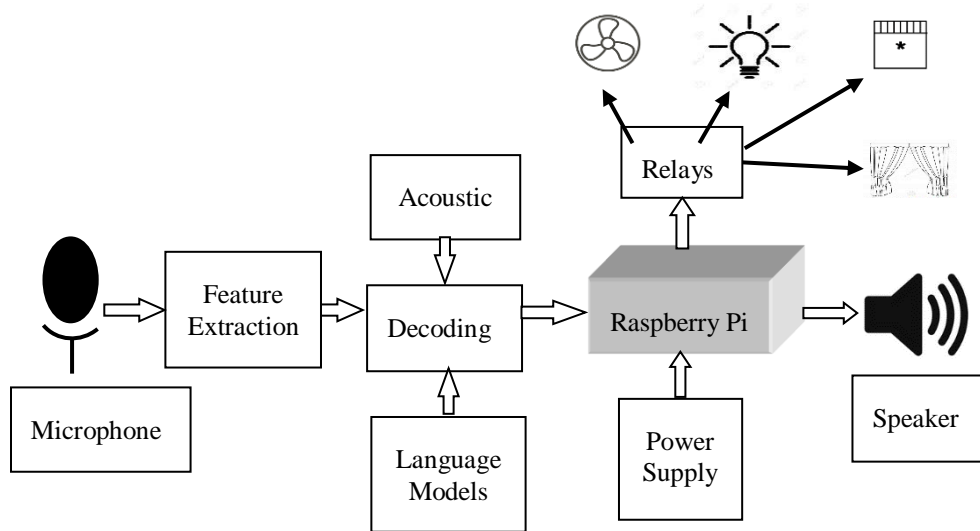

Figure 4.2: Diagram of the developed system

4.2.1 System Technology

The developed system implanted some of the technologies in other for it to function as designed. These technologies in way or the other facilitated the operation of the raspberry pi to execute the project.

30

4.2.1.1 Hardware

System hardware are the component of the system that are visible to the user. Hardware can also be referred to as the part of the primitive system that can be seen or touched by the user.

- *Raspberry pi*: Although Raspberry Pi was not the first SBC, the Raspberry Pi foundation makes the SBC available to nearly everybody and has exposed and made the GPIO connection pins very versatile. Software programs in the operating system are used to control this GPIO. The GPIO connects to assorted electronic devices and components. It also supports a variety of features such as interrupts, USB UART, SPI just to mention a few. This has prompted the prevalence of Raspberry Pi in teaching computer science as well as industrial use, researchers, model developers, gamers and the inquisitive. Because of its cost, it easily to be experimented with and damages due to wrong connection are tolerated then to have a personal computer blown up. The Raspberry Pi has become a core component of many complex projects in recent years. Figure 4.2 is a block diagram of the Raspberry pi**.**
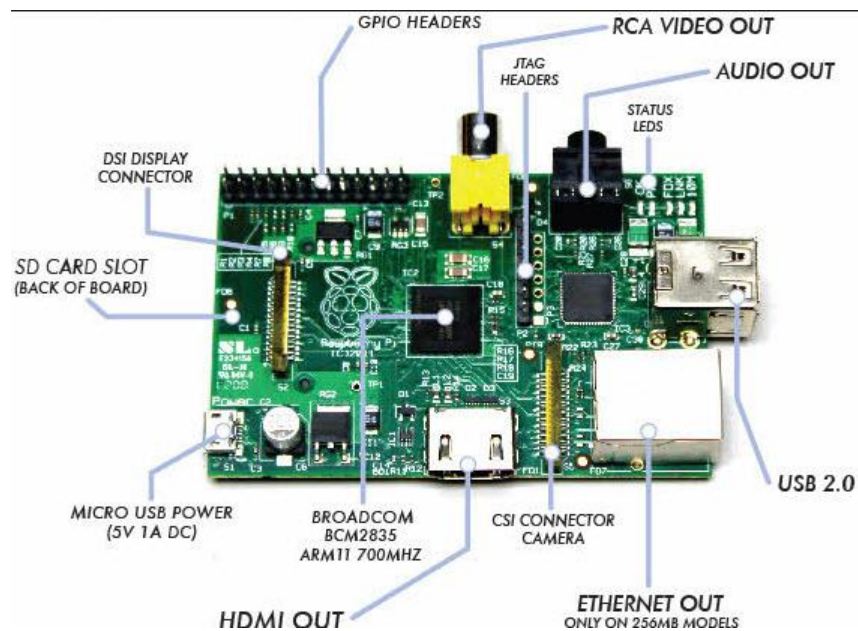

Figure 4.3: Hardware specifications of Raspberry Pi (Edgefxkits, 2018)

- *Servo Motor*: servomotor is a little linear actuator that efficient in the controlling of angular as well as linear movement of an attached object from one position to the other. It is often used in the implementation of robotic controls and automated controls (such as drilling and boring tools) just to mention a few (Büchler et al., 2019). Figure 4.4 below is a figure of a servo motor.

Figure 4.3a: Servo motor

- *Relays* : A relay is basically an electrical device that operates as an electrical switch. Its main use to make and break electrical contacts or circuits. It uses electromagnetism to open and close its contacts in other to achieve the aforementioned usage. But in recent technological advancement, there are relays that are solid-states. A contactor is another kind of relay that directly controls high voltages of supply to electrical loads. (Raja et al., 2018). Figure 4.5 is a picture of a four in one relay board.

Figure 4.3b: A four in one relay board of the developed system

- *Light-emitting diode (LED) and breadboard:* An LED is light is emanating from a semiconductor when current passes thought the semiconductor which has numerous advantages such as its size and its power consumption just to mention a few. They are usually employed in aviation light, billboards and traffic lights (Johnson, 2018).

A breadboard is also an essential component used to electronically test for prototype circuit. It is made up of plastics with holes, beneath these holes are electrical conductors to ensure electrical conduction between components (Kalka-Riffel et al., 2019). Figure 4.5 is a figure LEDs connected into the breadboard and a Raspberry pi.

Figure 4.3c: LED interconnected into the breadboard (Nguyen et al., 2018)

- *USB microphone for speech recognition:* For speech recognition to achieve the easiest way to ensure sound to enter a computer is to use a plug and play USB microphone. It is usually cross-platform that is windows Linux and Mac. It can also be used with mobile devices such as tablets phones and iPads without having to install or buy other peripheral devices. Figure 4.6 is a picture of a USB microphone used in the developed system.

Figure 4.3d: USB microphone

4.2.1.2 Software

This is referred to the part of the internal build and configuration of the system for effective functionality. Software of this primitive system can be referred to as the part of system that cannot be seen or touched.

- *Linux operating system:* Anand et al. (2012) in their study describes Linux as a free and open-source Unix-like software, primarily developed in C and assembly developed around Monolithic (Linux kernel) by Linus Torvalds. It is a multilingual software first released on September 17, 1999. Linux was initially created to be used by personal computers base on the Intel x86 design but currently runs on variety of devices ranging from mainframes,

supercomputers, mobile devices, embedded devices to servers (Tolu, 2018).The Linux operation system runs on a number of platforms: Hexagon, Itanium, Alpha, MIPS, and PowerPC. It also runs on OpenRISC, Nios II, RISC-V, PA-RISC, Xtensa, m68k, SuperH, NDS32, s390, SPARC, Unicore32. It is open-source, denoting the source code can be altered and used for both commercial and non-commercial for any purposes under the licenses of GNU General Public License. Arch Linux, CentOS, Debian, Fedora and Ubuntu are among the most popular and mainstream Linux distribution. Red Hat Enterprise Linux and SUSE Linux Enterprise Server are also among the popular commercial Linux distribution. There are other Linux distributions such as GNOME (a desktop environment), LXDE and LAMP modified distributions, for specific purposes.

- *Raspbian operating system*: Raspbian is an open-source Debian based operating system belonging to the Unix-Like family establish by the Raspberry Pi foundation and optimized for Raspberry Pi. The latest version is Raspbian Stretch with PIXEL/2018-06-27. Raspbian is the preferred operating system for Raspberry Pi contains about thirty five thousand software packages recompiled, in conjunction with educational, programming languages and general-purpose software (Harrington, 2015). The Raspbian uses Advanced Package Tool (APT) (an open-source software user interface together with core libraries updates) to uninstall and install software on Raspbian.

- *Programming languages*: Raspberry Pi has a significant number of programming language suitable for it. It for beginners, python is the suggested language by the Raspberry Pi foundation. Primarily, any programming language compiled for ARMv6 is runnable by the Raspberry Pi. Users are therefore not confined to utilize just the Python. C, C++, Java, Scratch, and Ruby are a few of the preinstalled languages on the Raspberry Pi. (Yli-Heikkilä, 2015)

- *Python for Raspberry Pi*: Python is a flexible, powerful and essay to use programming language developed by Guido van Rossum in the 1980s at the National Research Institute. Python has gained popularity in recent times and it is broadly utilized economically (Upton and Halfacree, 2012). It has clear and simple syntax making it user-friendly as well as an important language for bingers. Consequently, the RPi Foundation recommends it for Raspberry Pi. Python can be executed on a variety of operating, some examples are Windows, OS X and Linux published under an open-source license (Upton and Halfacree,

2012). Upton and Halfacree (2012) in their research described python as a cross-platform supported language and therefore compatible with other platforms, even though there are couple of exceptions of incompatible platforms. Python can be used in controlling some hardware such Raspberry Pi GPIO

4.3 Use-Case Diagrams

The visually impaired persons are supposed to say to the system which device to turn On or Off. The system detects the voice and the Raspberry pi upon recognizing the speech instruct the respective relay to either be open or closed. The sound output of the action taken is given to the visually impaired person in other for them to know that the action has been taken. Figure 4.8 is depiction how the functionalities of the system are performed.
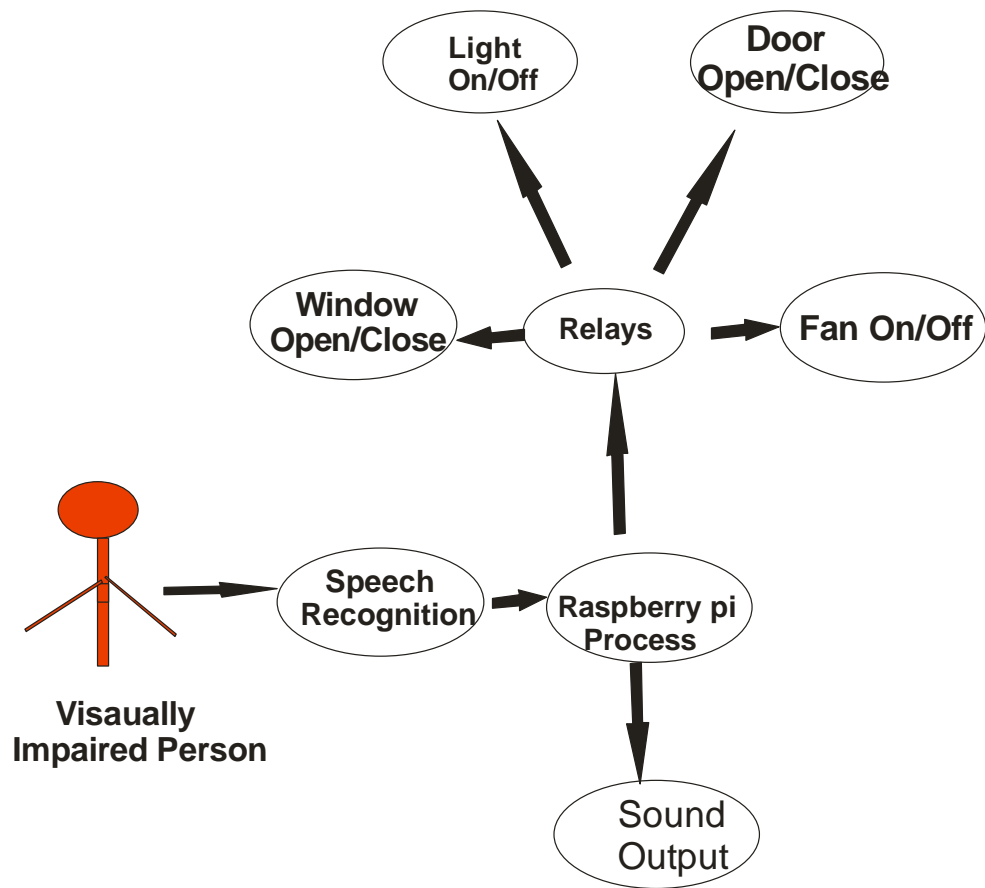
Figure 4.4: The developed systems use case diagram

4.4 Flowchart of the Developed System

In Figure 4.9 the flow chart diagram of the developed system is represented describing how the system is supposed to working and operate.
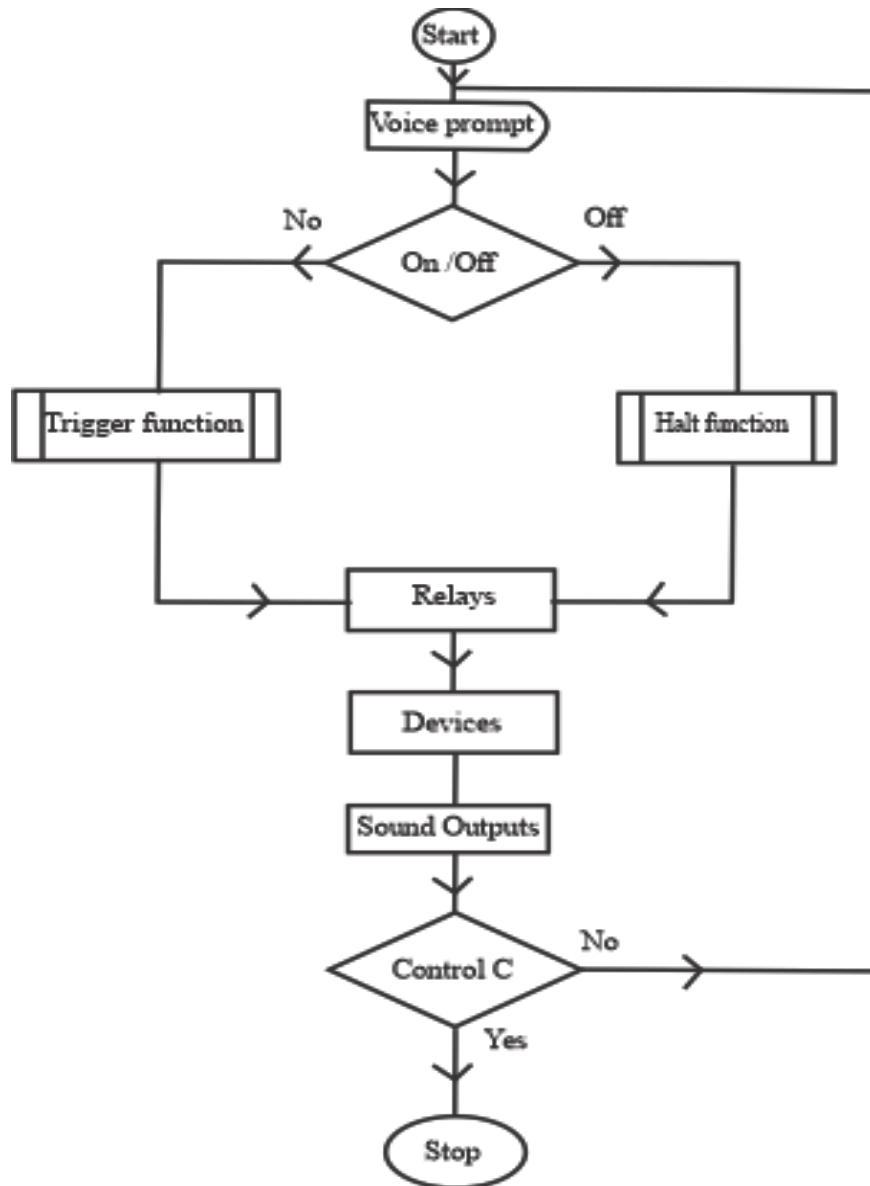

Figure 4.5: The Flowchart diagram of the developed system

4.5 Research Schedule

In Figures 4.6 and 4.7 shows the time frame of this project from start to finish. This representation of this project is represented in the Gant Chart as shown below. It stipulates the number of days allocated to each section of the project. Each task has a start and an end date. Each task is represented in block letters and the sub tasks in small letters:
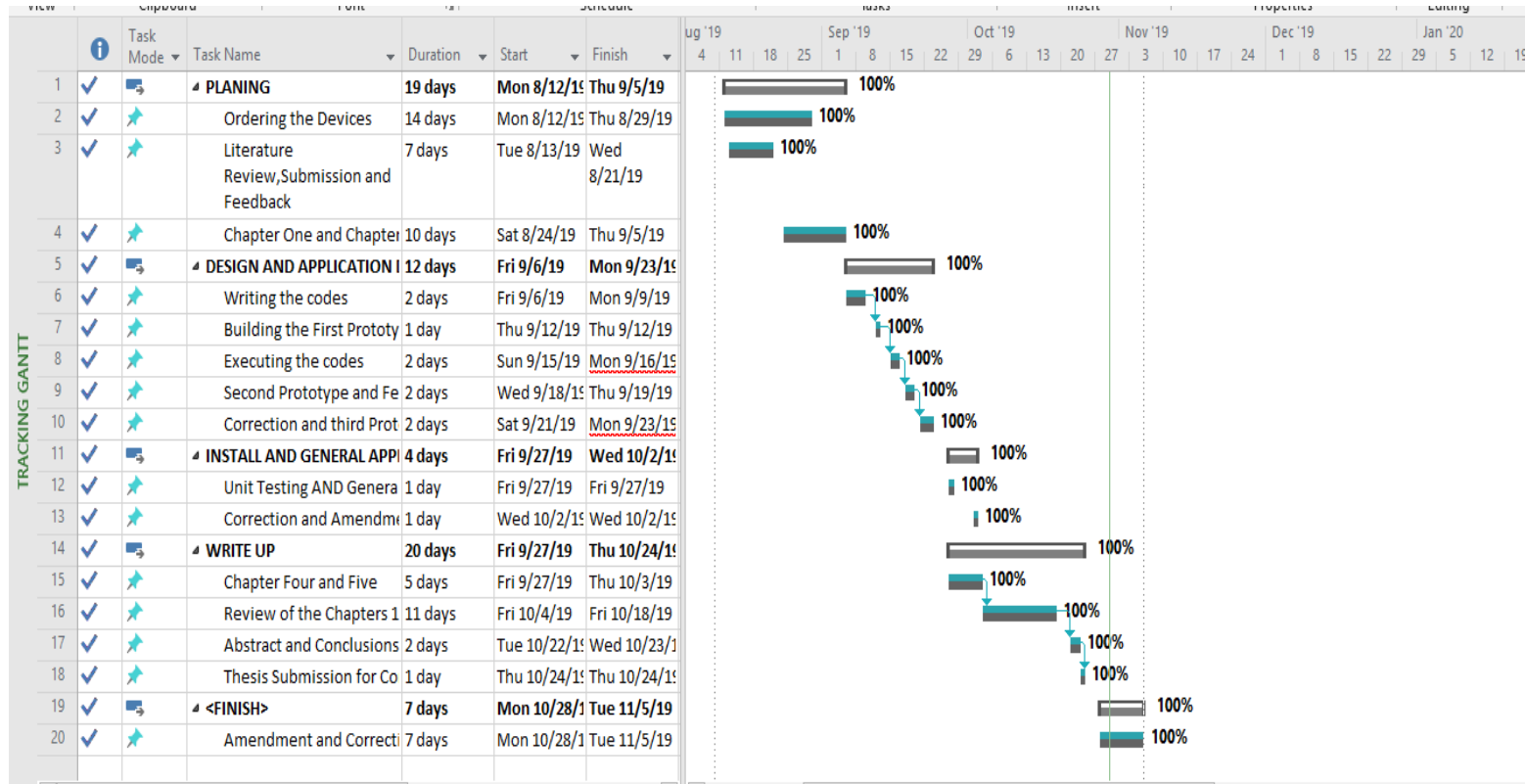
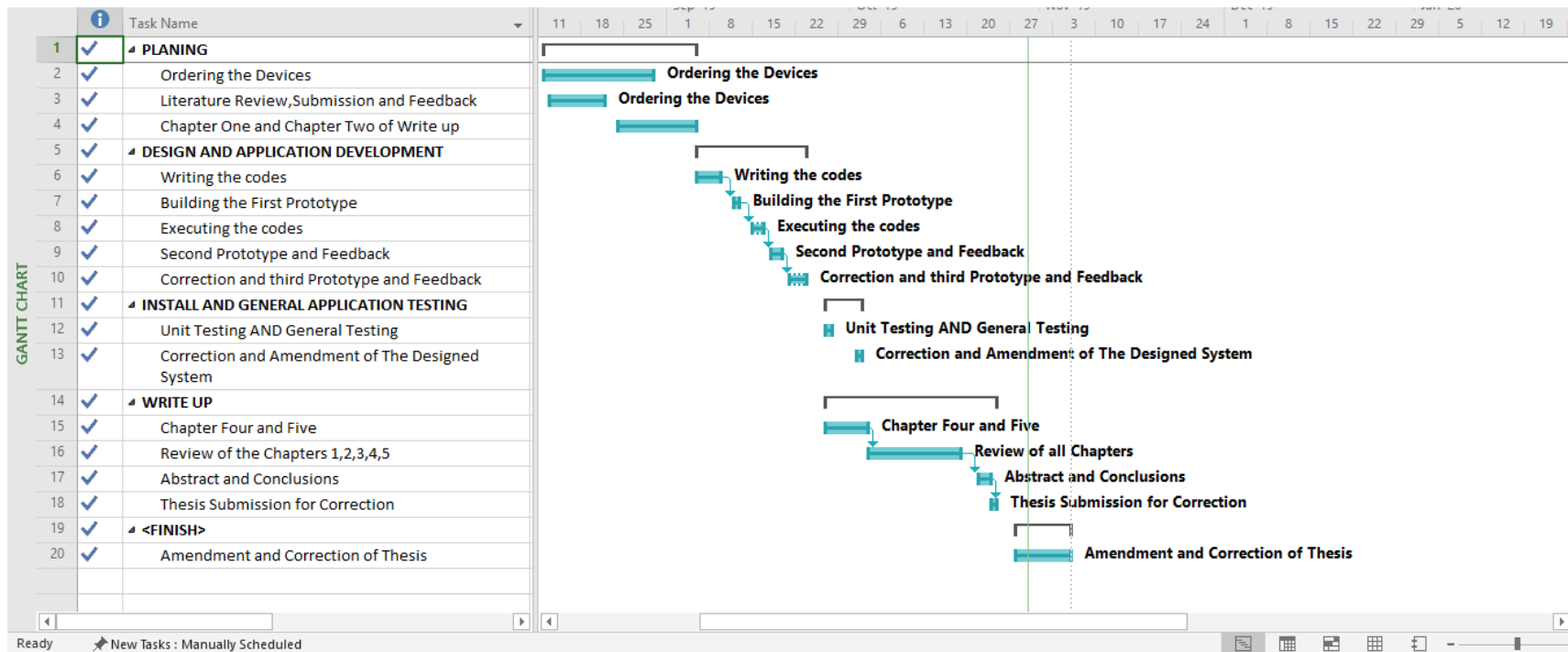**Figure 4.6:** Project schedule of the primitive system tracking the Gantt

Figure 4.7: Project schedule of the primitive system showing the Gantt chart view

CHAPTER 5

IMPLEMENTATION OF THE DEVELOPED SYSTEM AND RESULTS

In this chapter, the process of implementing the developed system was explained and demonstrated. The chapter feather presents the full description and explanation to the operation of the system and how it enables the visually impaired to with the help of a voice prompt control the devices is in the house. The chapter initially describes the setting up of the Raspberry Pi and later explains the other aspects of how the developed implemented.

5.1 Setting up Raspberry Pi

A Raspberry Pi 3 Model B was used in building this system, it has a RAM of 1GB capacity which is a quad-core processor as well. This enables it to handles bigger operating systems us as Ubuntu and Microsoft 10. The Raspberry 3 Pi has four USB port and HDMI port for video output.

- *Power supply***:** A 5V1 2.5A micro-USB power supply was used to power the Raspberry pi.
- *USB keyboard***:** A USB keyboard was used in the system.
- *USB mouse***:** A USB mouse was used in this system.
- *Micro SD card***:** A 16 GB micro SD card was used for storage in this system. NOOBS requires a minimum of 8GB storage.
- *Micro SD USB card reader***:** It was used to connect the micro SD card to a computer in order to install the downloaded the operating system.
- *A monitor***:** A fifteen-inch monitor was used for display**.**
- *An HDMI cable to serial convertor***:** It was used to aid in the connection of the monitor to the Raspberry Pi
- *An Ethernet cable***:** It is used for connection to the internet, an RJ45 internet cable was used. Connection with the Internet does not require configuration.

Steps carried out to set the Raspberry Up

Step 1: *Formatting the micro SD card*

The initial step was to reformat the micro SD because mostly new micro SD cards come with some irrelevant files on them. Therefore reformatting it completely delete and clear all files on the micro SD.

Step 2: Download NOOBS

NOOBS was then downloaded and installed onto the micro SD. Once this was done, the micro SD card was plugged into the Raspberry Pi. The operating system was then configured. NOOBS can be accessed through https://www.raspberrypi.org/downloads/ (Access date: 21/08/2019)

Step 3: *Initializing Raspberry Pi*

The micro SD card was inserted into the card socket of the Rasperry Pi 3.

A USB keyboard and USB mouse were plunged into the USB ports.

An HDMI to serial converter was utilized in connecting the Raspberry Pi to a monitor.

An RJ45 Ethernet cable was used to connect the Raspberry Pi to the internet.

Alternatively, a WiFi adapter of the Raspberry Pi could have been used to connect the system to the internet.

The 5.1 volts 2.5 amps micro USB power supply was used power up the Raspberry Pi device as supplied by the raspberry device producers.

*Step 4***:** *Download Raspbian*

Raspbian was downloaded and installed on the Raspberry Pi 3. It contains pre-compiled software and hundreds of projects use Raspbian as their operating system. Figure 5.1 is picture of Raspbain been Downloaded and installed.
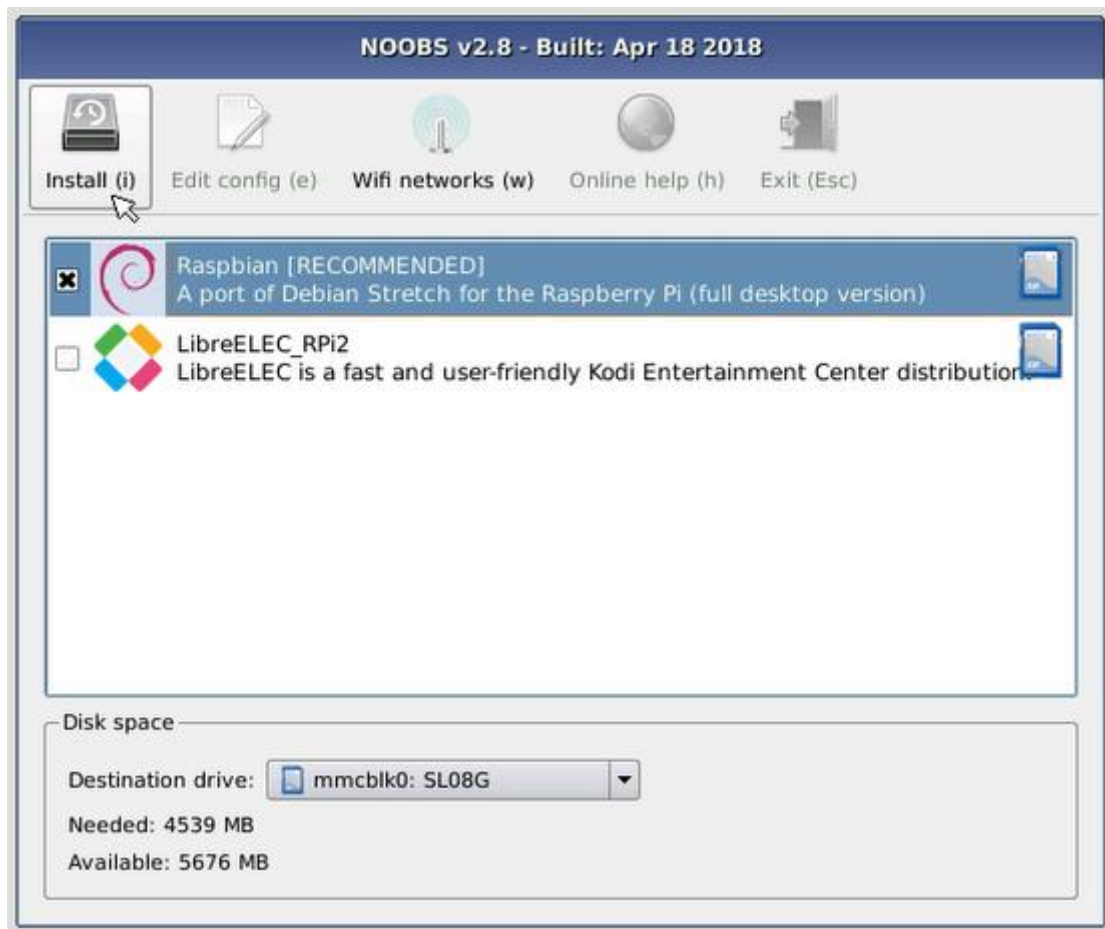
Figure 5.1: Downloading and installing Raspbian for the developed system

Once the installation was completed the Raspbian automatically began to boot.

Step 5: *Configuring Raspberry Pi 3*

Upon completion of the boot process, the location, date, and time.is done were configured to suit the local setting.

Menu → Preferences → Raspberry Pi Configuration → Localisation → Set Locale, Set time-zone and Set Keyboard are selected to set location, local time and keyboard language respectively.

After reconfiguring the Raspberry Pi, the system was rebooted. Once the Raspberry Pi was restarted, it was ready to be used.

5.1.2 Configuring and using GPIO pins

The Raspberry Pi 3, has 40 GPIO pins in total. Below is the GPIO pinout diagram of Raspberry Pi 3 used in this system.

3V3	1	2	5V		Key
GPIO2	3	4	5V		+
GPIO3	5	6	GND		Ground
GPIO4	7	8	GPIO14		UART
GND	9	10	GPIO15		I2C
GPIO17	11	12	GPIO18		SPI
GPIO27	13	14	GND		GPIO
GPIO22	15	16	GPIO23		Pin Number
3V3	17	18	GPIO24		
GPIO10	19	20	GND		
GPIO9	21	22	GPIO25		
GPIO11	23	24	GPIO8		
GND	25	26	GPIO7		
DNC	27	28	DNC		
GPIO5	29	30	GND		
GPIO6	31	32	GPIO12		
GPIO13	33	34	GND		
GPIO19	35	36	GPIO16		
GPIO26	37	38	GPIO20		
GND	39	40	GPIO21		

Figure 5.2: Label of GPIO

- **GPIO** are the standard pins used to input and output data into and out of raspberry pi. They generally do not have predefined purposes.
- **I2C** (Inter-Integrated Circuit) pins are synchronous packet-switched, single-ended serial computer bus that ensures connection and communication to hardware modules that support I2C Protocol, usually multi-master and multi- slave bus. It is used for inter-board communication within short distances
- **SPI** (Serial Peripheral Interface Bus) is used to ensure synchronous serial communication to SPI devices within short distances usually, in embedded systems.
- **UART** (Universal asynchronous receiver/transmitter) are serial pins utilized in transmitting asynchronous communication signals between the Raspberry Pi and other devices.

The Power pins output 3.3volts and 5volts DC power from Raspberry Pi.

- **GND** is used to connect the device to the ground electrically.
- **DNC** (do not connect) are usually left unconnected.

- **Configuring GPIO**

There is no need for configuration if the latest version of Raspbian is installed but ensuring successful running of the Raspbian, it had to be updated for the latest packages before commencing programming and utilizing the GPIO.

Running the following commands updated Raspbian:

```
# sudo apt-get update
```

```
# sudo apt-get upgrade
```

```
# sudo apt-get install rpi.gpio
```

5.2 Hardware Connection

Figure 5.3 is a circuit diagram of the developed system. In the diagram, the raspberry pi was connected to relays that intend to control the miniature appliances. The relays are connected in the normally open configuration.
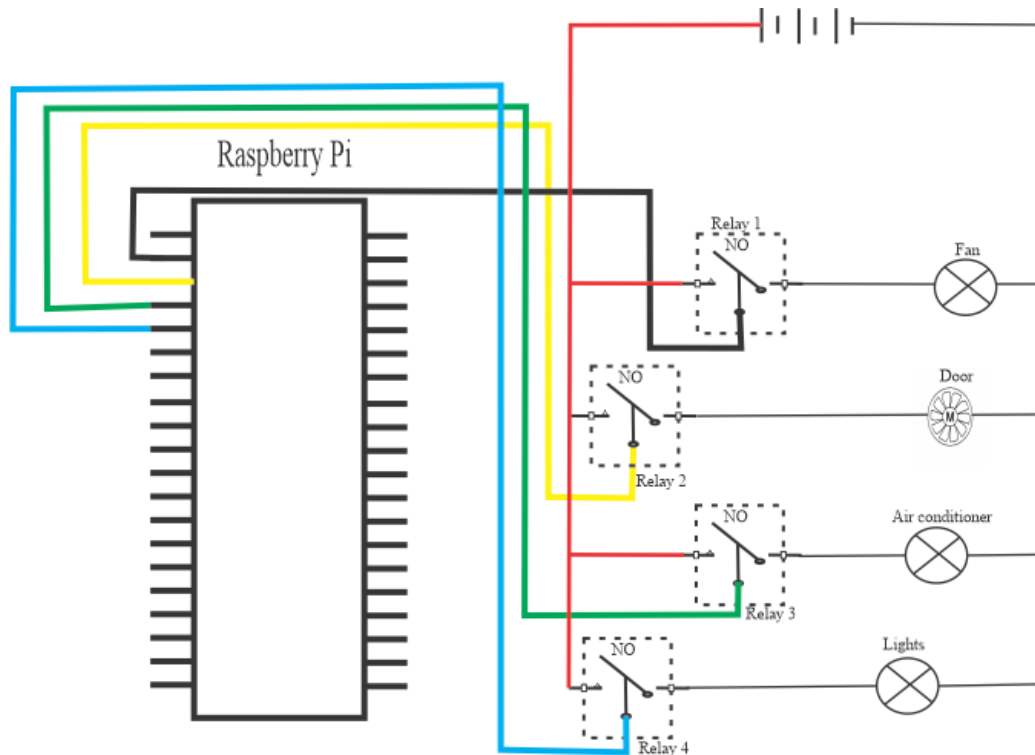

Figure 5.3: Circuit diagram of the developed system

5.3 Getting Python Ready for the USB Microphone

Step 1: Now, to ensure the latest version of the programs is running on the raspberry pi, the following commands are run to update the Pi.

```
#sudo apt-get update
#sudo apt-get upgrade
```

Step2: Python2.7 was used as the programming language in this system**.** Raspbian has an already installed python 2.7.

Step 3: Two libraries installed to make the python ready for speech recognition is Speech Recognition and PyAudio

The following codes are to be executed:

```
# pip install SpeechRecognition
```

PyAudio provides Python bindings for PortAudio, the cross-platform audio I/O library. With PyAudio, you can easily use Python to play and record audio on a variety of platforms, such as GNU/Linux, Microsoft Windows, and Apple Mac OS X / macOS.

Step 4: this code when will executed will help the python code to recognize the speech from the USB microphone from the user.

```
#!/usr/bin/env python
# _*_coding: utf8_*_


import speech_recognition as sr       # import the library


r = sr.Recognizer()                        # initialize recognizer

with sr.Microphone() as source:      # mention source it will be
either Microphone or audio files.

    print("Speak Anything :")

    audio = r.listen(source)            # listen to the source

    try:

        text = r.recognize_google(audio)     # use recognizer to
convert our audio into text part.

        print ("You said: {}". format(text))

    except:
```

```
        print ("Sorry could not recognize your voice") # In case
of voice not recognized clearly
```

5.4 Making The Raspberry Read Speak

This process explains how the preliminary system listens to commands and also speak to the visually impaired person.

5.4.1 Configuring text to speech

A software interface to convert text to speech was installed to enable the Raspberry Pi to read text aloud. A Text To Speech engine known as eSpeak was installed. The voice sounds a little robotic, however, it is able to runs without internet connectivity which is an added advantage for using eSpeak.

Step 1: First step was to test the audio of the Raspberry Pi with the following command:

```
aplay /usr/share/sounds/alsa/*
```

sounds output "Front Center"," Front Left", "Front Right" and so on, was heard indicating that it was working.

Step 2: The next step was to install eSpeak. This command was executed to in terminal to install espeak:

```
sudo apt-get install espeak
```

Step 3: to test for successful installation the following command was executed to get the Raspberry Pi Speaking.

```
espeak "Text you wish to hear back" 2>/dev/null
```

```
espeak "Hello World" 2>/dev/null
```

"Text you wish to hear back" and "Hello World" was heard from the speakers.

5.4.2 Operational procedure

For this Preliminary system, the word phrase "Raspberry" is seen by the system as the activation phrase to activate the raspberry to listen to the command thereafter for execution. The operational steps are as follow:

- The system boots and gets ready for operation.
- The microphone is ready to accept voice commands.
- The microphone only takes in words with the key word "Raspberry" at the beginning.

- The voice library recognizes the spoken command and then it is moved to the speech recognition system which convert the speech to text to be interpreted by the Raspberry Pi.

- The Raspberry Pi interprets the information from the speech recognition system to control the appliances through closing and opening of relays.

- The information is then moved back to the speech recognition system which converts that information to audio files that is heard as the output command from the speakers.

Table 5.1 shows the valid voice command spoken to this preliminary system and the output

Table 5.1: Valid voice command and appliance controlled/voice output.

VOICE COMMAND (INPUT)	HOME APPLIANCE CONTROLLED	VOICE OUTPUT
Raspberry on fan	Fan	Fan is on
Raspberry off fan	Fan	Fan is off
Raspberry on light	Light	Light is on
Raspberry off light	Light	Light is off
Raspberry open door	Door	Door is opened
Raspberry close door	Door	Door is closed
Raspberry open window	Window	Window is opened
Raspberry close window	Window	Window is closed

5.5 Testing The Developed System

Five (5) visually impaired persons was used to test this Primitive system to ascertain the accuracy of the system. The persons where between the ages of 18 to 65, they were three (3) males and two (2) females. They were all Nigerians used for this testing and they were found around the system developer's residence.

Table 5.2: Test outcome of the Primitive system by 5 visually impaired persons

		FAN		LIGHT		DOOR		WINDOW	
		Fan on	*Fan off*	*Light on*	*Light off*	*Door open*	*Door close*	*Window open*	*Window close*
VISUALLY IMPAIRED 1	**1st Attempt**	√	√	√	√	√	√	√	−
	2nd Attempt	√	√	√	√	√	√	√	√
VISUALLY IMPAIRED 2	**1st Attempt**	√	−	√	√	√	√	√	√
	2nd Attempt	√	√	√	√	−	−	√	√
VISUALLY IMPAIRED 3	**1st Attempt**	√	√	√	√	√	√	√	√
	2nd Attempt	√	√	√	√	√	√	√	√
VISUALLY IMPAIRED 4	**1st Attempt**	√	√	√	−	√	√	√	√
	2nd Attempt	√	√	√	√	√	√	−	−
VISUALLY IMPAIRED 5	**1st Attempt**	√	√	√	√	√	√	√	√
	2nd Attempt	√	√	√	√	√	√	√	√

5.5.1 Error Rate

Grooves and Lyberg (2010) defined Error rate as a concept that purports to describe statistical properties of survey estimates, incoperating a variety of error sources. Error are variance component models measuring the portion of instability in an estimate due to some features of the essential survey conditions(e.g. pronunciation & diction). For the testing carried out by the five(5) persons, the following results where obtained.

Total number of outcome = 80

Total number of failed outcomes = 7

Percentage of failed outcome = 8.75%

Percentage of accurate outcome = 91.25%

The testing showed that there was 8.75% error rate noticed in the system which was predominantly caused by pronounciation & diction by the testers. It therefore goes forward to show that the Preliminary system was 91.25% accurate during testing.

Figure 5.4: Visually Impaired person testing the developed system

CHAPTER 6
CONCLUSION AND RECOMMENDATIONS

This chapter talks about the test result from the Preliminary system, if the outcome of the test was satisfactory to the visually impaired and the future recommendations for this preliminary system to future researchers.

6.1 Conclusion

Smart home automation has become a necessity for every home. Its use has been increasing over the last decade, as more people are increasingly demanding for their homes to be automated. Although some people with specific disability have been able to automate their homes, people with visual (eye) disability are increasing in the world and wish for their homes to be automated too. This paper describes the development of a voice automation system, which visually impaired persons (blind) can use to control home appliances and give feedback audibly to the visually impaired person. With the help of this Preliminary system, people with visual impairment can easily control anything in their homes without help from anyone.

6.2 Recommendations

The primitive system described in this study can be developed further by considering the following suggestions:

- This primitive system can be more beneficial to visually impaired persons if the mode of communication with the developed system is through wireless microphone. This will enhance the mobility of the user.
- This primitive system can be universal if it can communicate and respond with other languages other than English.
- The primitive system can be more beneficial also if it can be implemented in a mobile device, preferably on a mobile phone or a tablet.
- The primitive system can be adapted for other operating systems.
- The primitive system can also be useful and beneficial to able-bodied persons who intend to automate their homes

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APPENDICES

APPENDIX 1

SOURCE CODE OF THE DEVELOPED SYSTEM

```
import speech_recognition as sr

import pyttsx3

import RPi.GPIO as GPIO

import time

GPIO.setmode(GPIO.BCM)

GPIO.setwarnings(False)

####################################################

##  Step 1: Initialize New GPIO Pin for New Device Here.

#For Example I initialize new GPIO pin 6 for AC


#Pin Initialization for Window no. 1

W1=6

#Pin Initialization for Fan no. 1

F1=26

#Pin Initialization for Gate no. 1

G1=19

#Pin Initialization for Light no. 1

L1=13


#------------------------------------------------#

# Step 2: Initialize Status flag of new Device

#, For Example, I initialize the status flag for AC


#Status Initailization for Window no. 1
```

WS1=0

#Status Initailization for Fan no. 1

FS1=0

#Status Initailization for Door no. 1

GS1=0

#Status Initailization for Light no. 1

LS1=0

#---#

###

Step:3 Set Mode of Pin as Output

For Example for AC I set AC Pin as Output

Set Pin Mode as OUTPUT

GPIO.setup(W1,GPIO.OUT)

GPIO.setup(F1,GPIO.OUT)

GPIO.setup(G1,GPIO.OUT)

GPIO.setup(L1,GPIO.OUT)

#---#

##

Step:4 Set Pin HIGH to off Device when program run initially

For Example for AC I set AC Pin HIGH

Relay Switch on Logic LOW.

Set all Pins HIGH to off initially all things

GPIO.output(W1,GPIO.HIGH)

GPIO.output(F1,GPIO.HIGH)

GPIO.output(G1,GPIO.HIGH)

GPIO.output(L1,GPIO.HIGH)

```
#############################################
# Initialize Recognizer
#Sample rate
sample_rate = 48000
chunk_size = 2048
r = sr.Recognizer()
def speakback(text):
    engine = pyttsx3.init()
    engine.say(text)
    engine.runAndWait()


def SetPin(pinName,Condition):
    if(Condition==1):
        GPIO.output(pinName,GPIO.HIGH)
    else:
        GPIO.output(pinName,GPIO.LOW)


while (1):
    with sr.Microphone(device_index = 1, sample_rate = sample_rate,chunk_size = chunk_size)
        as source:
        r.adjust_for_ambient_noise(source)
        print("Speak Anything:")
        audio=r.listen(source);


        try:
            text=r.recognize_google(audio)
```

```python
        print(text)

        t1=str(text)

        t1=t1.split()


        if(t1[0]=='raspberry'):

            text=t1[1]+' '+t1[2]

            if(text=='on fan' or text=='on fun'):

                SetPin(F1,0)

                FS1=1

                speakback('Fan is On')

            elif(text=='off fan' or text=='of fan' or text=='off fun' or text=='of fun' or text== 'pi
fan' or text== 'pi fun' ):

                SetPin(F1,1)

                FS1=0

                speakback('Fan is Off')

            elif(text=='open Gates' or text=='Open Gate'):

                SetPin(D1,0)

                DS1=1

                speakback('Gate' 'is' 'opened')

            elif(text=='close Gates' or text == 'closed Gates' or text== 'close Gate'):

                SetPin(D1,1)

                DS1=0

                speakback('Gate is closed')

            elif(text=='on lights' or text=='on light'):

                SetPin(L1,0)

                LS1=1
```

```python
        speakback('light is On')
    elif(text=='off lights' or text=='of light'or text=='off light'):
        SetPin(L1,1)
        LS1=0
        speakback('light is Off')
    elif(text=='open window' or text=='Open Window'):
        SetPin(W1,0)
        WS1=1
        speakback('Window is opened')
    elif(text=='close window' or text=='Close window'):
        SetPin(W1,1)
        WS1=0
        speakback('Window is closed')
#--------------------------------------------------------#

    elif(text=='status fan'):
        if(FS1==0):
            speakback('Fan is Off')
        else:
            speakback('Fan is On')
    elif(text=='status Gate'):
        if(GS1==0):
            speakback('Gate is closed')
        else:
            speakback('Gate is opened')
    elif(text=="status light"):
```

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```python
        if(LS1==0):

            speakback('Light is Off')

        else:

            speakback('Light is On')

    elif(text=='status window'):

        if(WS1==0):

            speakback('Window is closed')

        else:

            speakback('Lindow is Opened')

    #--------------------------------------------------------#


else:

    speakback('Invalid Command')

except:

    speakback('Invalid Command')
```

APPENDIX 2

THE DEVELOPED SYSTEM
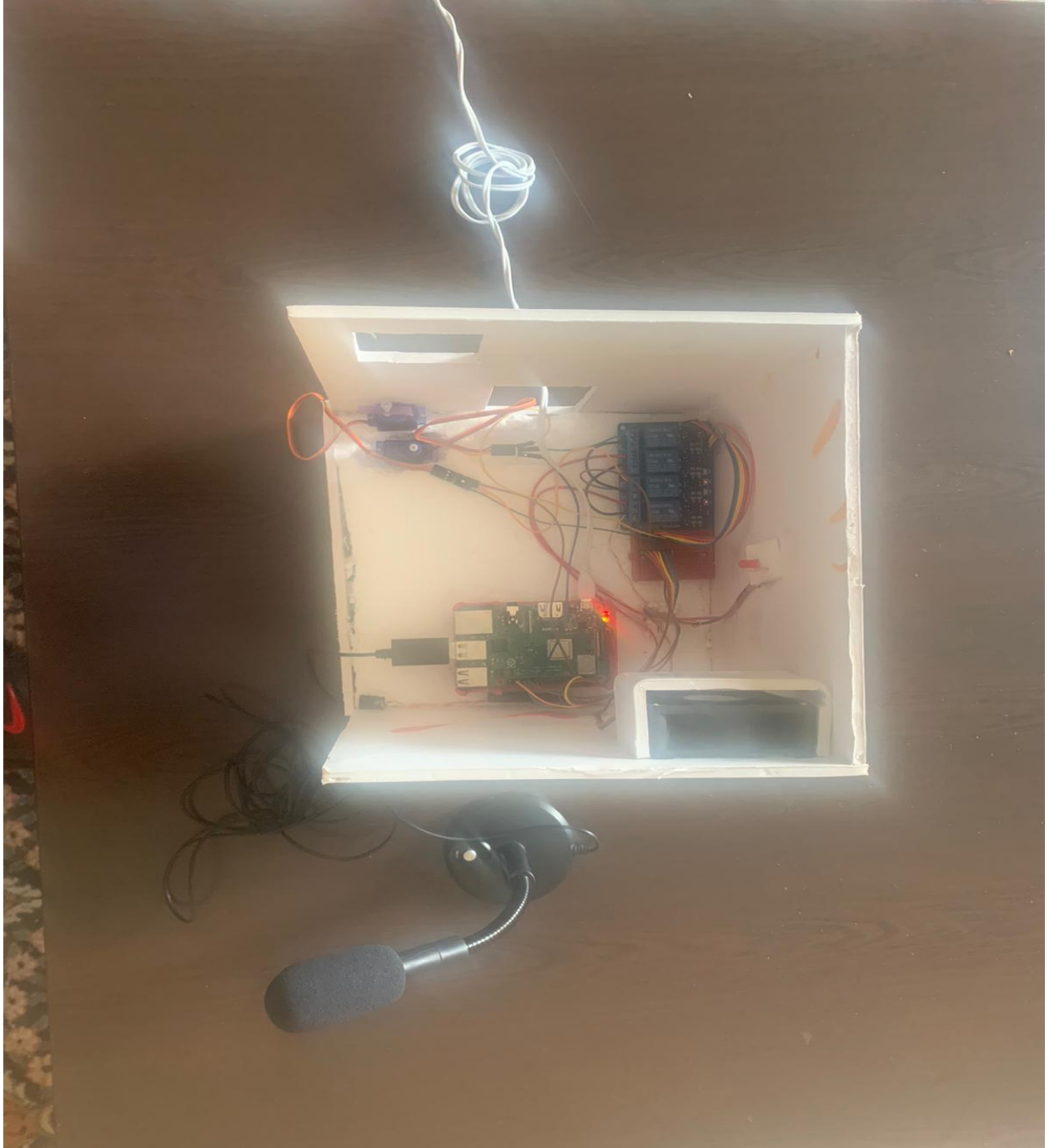
APPENDIX 3

IMAGES OF TESTERS USING THE PRELIMINARY SYSTEM

APPENDIX 4

SIMILARITY RESPORT

APPENDIX 5

APPROVED ETHICAL COMMITTEE LETTER

NEAR EAST UNIVERSITY

GRADUATE SCHOOL OF APPLIED SCIENCES

DEPARTMENT OF COMPUTER INFORMATION SYSTEMS

10/09/2019

Dear OLUMENSE GOODNESS AGHEDO

Secondary data will be used in the thesis titled "*SMART HOME AUTOMATION FOR VISUALLY IMPAIRED USING RASPBERRY PI*" it does not need to go through the ethics committee. You can start your research on the condition that you will use only secondary data.

Prof. Dr. Nadire Cavus
Supervisor