Chapter 1 - Introduction

Chapter 2 - Server establishment, IoT and NLP implementation

The motive of this project is to develop a full fledged server with support to latest technologies developing in the market. That is -

1. Provide IoT support
2. Provide cloud support
3. Provide machine leaning and artificial intelligence support

It combines technologies of various fields into a one unique machine. Use of various programming languages is take like -

1. Python
2. C ++
3. C
4. Java
5. Bash scripts/Terminal scripting
6. MySQL query language
7. HTML

IoT helps in interfacing the virtual world with the physical world, while generating enormous amount of data which can be stored inside the cloud server and proper and easy LAN and WAN access of that data is made possible only with the help of cloud server. While the generated data need to be processed to fetch some meaning and value to the business which is supported with the help of technology called machine leaning and artificial intelligence.

Python is used to create bash scripts and implement the technology of computer vision in this project while C and C++ is used to program the micro controllers.

HTML, JAVA, MySQL and others are used to develop the web interface to provide user support and make the server capable of data protection, access and user credential protection.

The motive of this project is to make a wast scope idea that have its implementation in day to day life by providing and easy mind controlled appliance that allow user to control the power of appliance just by thinking by using EEG, computer vision and IoT.

Second motive of this project is to allow speech controlled environment for have, provide security and real time surveillance to each and every home and provisioning a secure way of data access i.e a self hosted cloud in a cheap yet affective way.

Chapter 3 - Server Side Utilities

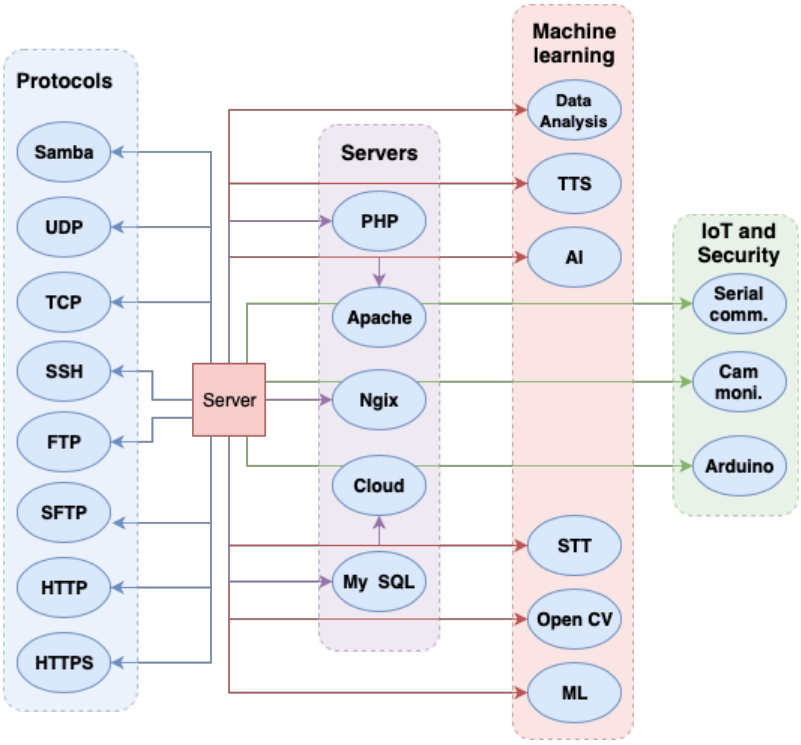

Figure 3.1 Utilities and facilities running on server

Server side is consist of 4 different parts i.e

1. Protocols
2. Servers technologies
3. Machine Learning and AI based technologies
4. IoT and Security Technologies

Protocol – These are the set of rules that are used to implement various technologies for the management and controlling the working of various services inside the server side. Like MIME for email service activation as soon as the server starts, a cloud server scripts begin to run that takes screen short of the screen and send the created screen capture to defined email using MIME protocol. SSH is used to login remotely and etc.

Server Technologies – This contains various different technologies from different vendors which when combined provides services of website hosting, database management, controlling and file access.

Machine Learning and AI based technologies – These contains technologies related to artificial intelligence and machine learning. From speech to text conversion, to text to speech conversion, detection of objects, human faces, posture and movement is managed by this field only, it also provides data analysis and visualisation for the generated data.

IoT and Security Technologies – These contains using the latest technologies like IoT i.e internet of things. It helps in automated heat management of the system, remotely controlling devices and

appliances, to authentication using RFIDs, It uses microcontrollers like raspberry pi and arduino with several sensors connected to it.

As shown in figure 3.1, left side shows 8 protocols running:

1. Samba
2. UDP
3. TCP
4. SSH
5. FTP
6. SFTP
7. HTTP
8. HTTPS

Samba – It is used to create a NAS storage at the LAN level to support a simple file accessing system using Samba protocol to the mounted drives attached to the storage.

UDP – It is a fast data transfer protocol, that sends data without expecting a acknowledgment hence making the process fast, and is used mostly for vide streaming where few lost package does not destroy the integrity of the data.

TCP – On the other hand TCP waits for the acknowledgement after the transfer of package from one user to another and is used to transfer data like documents, and data whose integrity is crucial. It is slow but no data is lost as the lost data is sent again if no acknowledgment is recieved.

SSH – Secure shell is used to remotely login into the system and access the system using the shell i.e terminal in Linux and OSX and powershell in windows. It uses port 22.

FTP – File transfer protocol as the name suggest is used to transfer file between two remotely located but interconnected over network systems. Samba is freely available, unlike other SMB/ CIFS implementations, and allows for interoperability between Linux/Unix servers and Windows-based clients. File Transfer Protocol (FTP) is a standard network protocol used to exchange and manipulate files over a TCP/IP based network, such as the Internet.

SFTP – Shell file transfer protocol, uses SSH protocol for the transfer of file between two remote systems.

HTTP – Is an old protocol used to display websites, locally port 80 is open and is allowed by the firewall to make and accept request on the internet.

HTTPS – Is a secure HTTP protocol, Instead of HyperText Transfer Protocol (HTTP), the website uses HyperText Transfer Protocol Secure (HTTPS). Using HTTPS, the computers agree on a "code" between them, and then they scramble the messages using that "code" so that no one in between can read them. This keeps your information safe from hackers. They use the "code" on a Secure Sockets Layer (SSL), sometimes called Transport Layer Security (TLS) to send the information back and forth.

MIME – MIME (Multi-Purpose Internet Mail Extensions) is an extension of the original Internet e-mailprotocol that lets people use the protocol to exchange different kinds of data files on the

Internet: audio, video, images, application programs, and other kinds, as well as the ASCII text handled in the original protocol, the Simple Mail Transport Protocol (SMTP). In 1991, Nathan Borenstein of Bellcore proposed to the IETF that SMTP be extended so that Internet (but mainly Web) clients and servers could recognize and handle other kinds of data than ASCII text. As a result, new file types were added to "mail" as a supported Internet Protocol file type.

Figure 3.1, shows 5 servers running:

1. PHP
2. Apache
3. Ngix
4. Cloud
5. My SQL

PHP – PHP is a general-purpose scripting language that is especially suited to server-side web development, in which case PHP generally runs on a web server. Any PHP code in a requested file is executed by the PHP runtime, usually to create dynamic web page content or dynamic images used on websites or elsewhere.

Apache – Apache is the most widely used web server software. Developed and maintained by Apache Software Foundation, Apache is an open source software available for free. It runs on 67% of all webservers in the world. It is fast, reliable, and secure.

Nginx – The NGINX web server can act as a very capable software load balancer, in addition to its more traditional roles serving static content over HTTP and dynamic content using FastCGI handlers for scripts. Because NGINX uses a non-threaded, event-driven architecture, it is able to outperform web servers like Apache.

Cloud – The cloud server is based on Google Driver type technology which is called nextCloud a fork that developed from ownCloud is used for easy drag and drop cloud based technologies which support various features like, social networking, video calling, device tracking, office document editing and management, note taking, etc. The cloud server uses PHP, My SQL and Apache server and is hosted on port 80 i.e HTTP and HTTPS is used.

My SQL – It is based on a client-server model. The core of MySQL is MySQL server, which handles all of the database instructions (or commands). MySQL servers available as a separate program for use in a client-server networked environment and as a library that can be embedded (or linked) into separate applications.

Figure 3.1, shows 6 ML and AI facilities running:

1) Data Analysis
2) TTS
3) STT
4) AI
5) Open CV
6) ML

Data Analysis – Data analysis can be performed with the help of pre designed scripts developed in python programming language and combined with the bash shell scripts just requires the input of

data as the argument along with the input hence making a robust and easy to maintain and modify with changes in future.

TTS – Text to speech is also performed as the user speaks that spoken language is analysed with the help of speech to text technology and that text is transferred over network to the local server for processing in the voice command script. Full description of the functioning will be provided in further document.

STT – Speech to text, this technology is being used at both client and server. When client provides a predefined command to the machine by running the hello.py script in python language that first asks for the host or server IP address that is running the analysis for the converted speech to text and then the commanded task is performed. Full description of the functioning will be provided in further document.

AI – Artificial in itself is a very wide and vast topic and high level implementation requires better processing power. But due to the limited processing power and working in the ability of the knowledge AI here is used for training the Open CV models hence help in creation of harcascades for face detection and object detection that takes input in form of 10000 test cases consisting of several images.

Open CV – It is a well known image processing library that supports from small objects a like microbes to huge objects like starts and planets. Here the used Open CV library are of volume 3 and volume 4. It is used for object and face detection based on the machine and server trained xml(s) of harrcascades.

ML – Machine leaning technology is used in machine in form of data visualisation for the creation of graphs and predication modles.

Figure 3.1, shows 3 IoT and Security facilities running:

1. Serial Communication
2. Monitoring over webcam
3. Arduino *dev*/ttyACM0

Serial Communication – The server hosting hardware is connected to the small microcontrollers like arduino which are connected to the sensors and the server is directly controlling those microcontrollers using serial ports of USB 2.0. All the data received is stored into data files and serial in opened to send and receive data for commanding and performing tasks in physical world. Serial communication here is a true interface between the software and the physical world.

Monitoring over webcam – The server provides security in form of real time surveillance and monitoring using the usb 2.0 webcam attached to one of its serial port. The webcam surveillance uses the port 8080 of the local host which when exposed to public IP helps in proper monitoring of the surroundings inside the local network or over WAN.

Arduino – *dev*/ttyACM0 is the port to which arduino number one is connected which transfers data related to heat of the system, controlling fans and lights and appliance connected to it using and relay, humidity details and PM 2.5 details.

Chapter 4 Server Side open ports

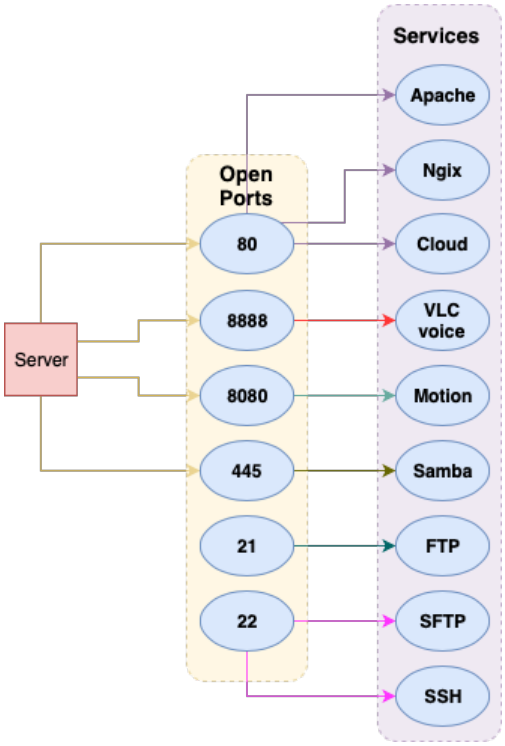

Figure 4.1 open port available on server side

Figure 4.1. shows, server side is consist of 4 different parts i.e

1. 80
2. 8888
3. 8080
4. 445
5. 21
6. 22

Port 80 – It is used mainly for the internet, and all the request from and to internet goes through port 80. most of the firewall allow the request from port 80 and is open by default. It uses protocols like http and https. Here in the project port 80 is used for hosting servers like Apache and Nginx. While the cloud storage hosted on Apache can also be easily accessed over this port 80.

Port 8888 – This port is opened when a script is run accessed using ssh, as soon as the scripts run it open a port on the remote server playing an MP3 file as out.mp3. Which is basically outputting the sound which is being heard by the speakers connected to the servers hardware allowing to hear what is all playing onto and around the server.

Port 8080 – It opens a motion service. When motion service is started using 'sudo service motion start' command onto the server shell, it activates the webcam which can be seen on the remote servers port 8080. Can be accessed using a web browsers as 'Servers.ip.address.inbrowser:8080'.

Port 445 – Samba service for file management is hosted onto the port 445, which gives the server a unique open port that allow the bind drives to the server to be accessed remotely inside the LAN and can be used to access over WAN, if the local host have a public domain attached to it. t is used to create a NAS storage at the LAN level to support a simple file accessing system using Samba protocol to the mounted drives attached to the storage.

Port 21 – Port 21 is famously known for service of FTP. File transfer protocol as the name suggest is used to transfer file between two remotely located but interconnected over network systems. Samba is freely available, unlike other SMB/CIFS implementations, and allows for interoperability between Linux/Unix servers and Windows-based clients. File Transfer Protocol (FTP) is a standard network protocol used to exchange and manipulate files over a TCP/IP based network, such as the Internet.

Port 22 – SSH service uses this port 22 to allow remote login to the server from anywhere and from any client machine inside the LAN or over WAN if the server ip is forwarded to some public domain or Public IP. Secure shell is used to remotely login into the system and access the system using the shell i.e terminal in Linux and OSX and powershell in windows. hell file transfer protocol, uses SSH protocol for the transfer of file between two remote systems.

Chapter 5 - Voice control

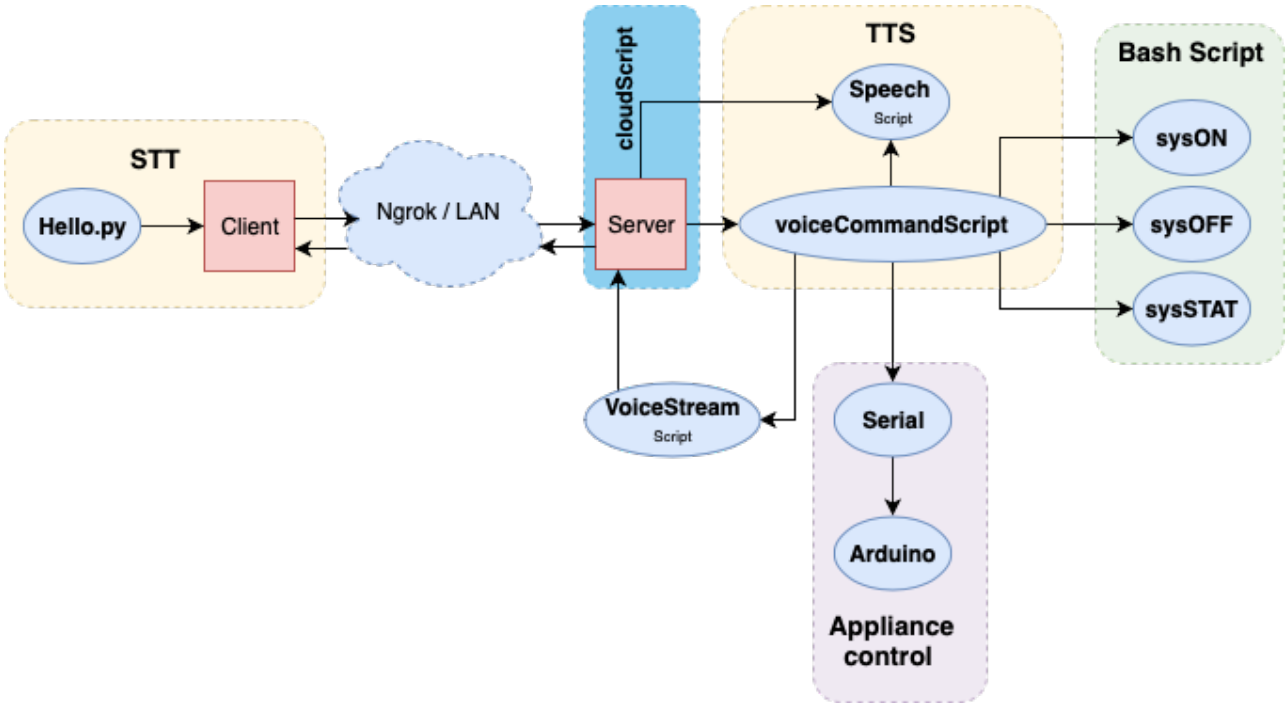

Figure 5.1 Voice control mechanism

Figure 5.1 show the complete flow of the voice control mechanism followed between client and server.

The complete architecture for voice control is divided into 7 components, all the components have sub parts inside it. Those parts are -

1. STT
2. Interconnection (Nrgrok/LAN)
3. CloudScript
4. TTS
5. Bash Scripts
6. Application Control
7. VoiceStream script

STT – Client running the provided python script called hello.py inside the python 3 environment, while being connected to the internet the client can communicate and command the remote server with his speech using the speech to text conversion.

Interconnection (Nrgrok/LAN) – This explains how the internconnection or the communication will establish between the client and the server. It uses two ways of establishing the connection i.e -

1. Locally – LAN – Inside the same network of the router having common gateway and starting class C IP address, which support 254 hosts.

```
  GNU nano 2.7.4

authtoken: 77tJD1gbQrmA3n1Qgp4eZ_4i8hEXkQaDLDdzz8wfHFm
tunnels:
  SSH:
    addr: 22
    proto: tcp
  nextcloud:
    addr: 80
    proto: http
```

Figure 5.2 ngrok configuration file

```
  GNU nano 2.7.4                                                File: /bin/cloudSc

#! /bin/bash

file="/home/pi/cloudScript.temp"
if [ ! -f "$file" ]
then
        echo '[WARNING] ngrok Instance created, Please do not deleted it!' >/home/pi/cloudScript.temp
        sleep 2s
        ngrok start -all & p1=$!
        sleep 8s
        echo "Now taking Snapshot"
        sleep 2s
        import -window root Network.png & p2=$!
        echo "Now Sending mail....."
        sleep 6s
        mailScriptPython
        wait -n
        [ "$?" -gt 1 ] || exit "$p2"
        wait
else
        echo "File" $file "exist"
fi
```

Figure 5.3 cloudScript

2. Globally – Ngrok – It is a free plan service which helps in forwarding a local machine to a port hosted by the ngrok servers, hence allowing easy access to local machine globally from anywhere without having the need to forward port on the router device.

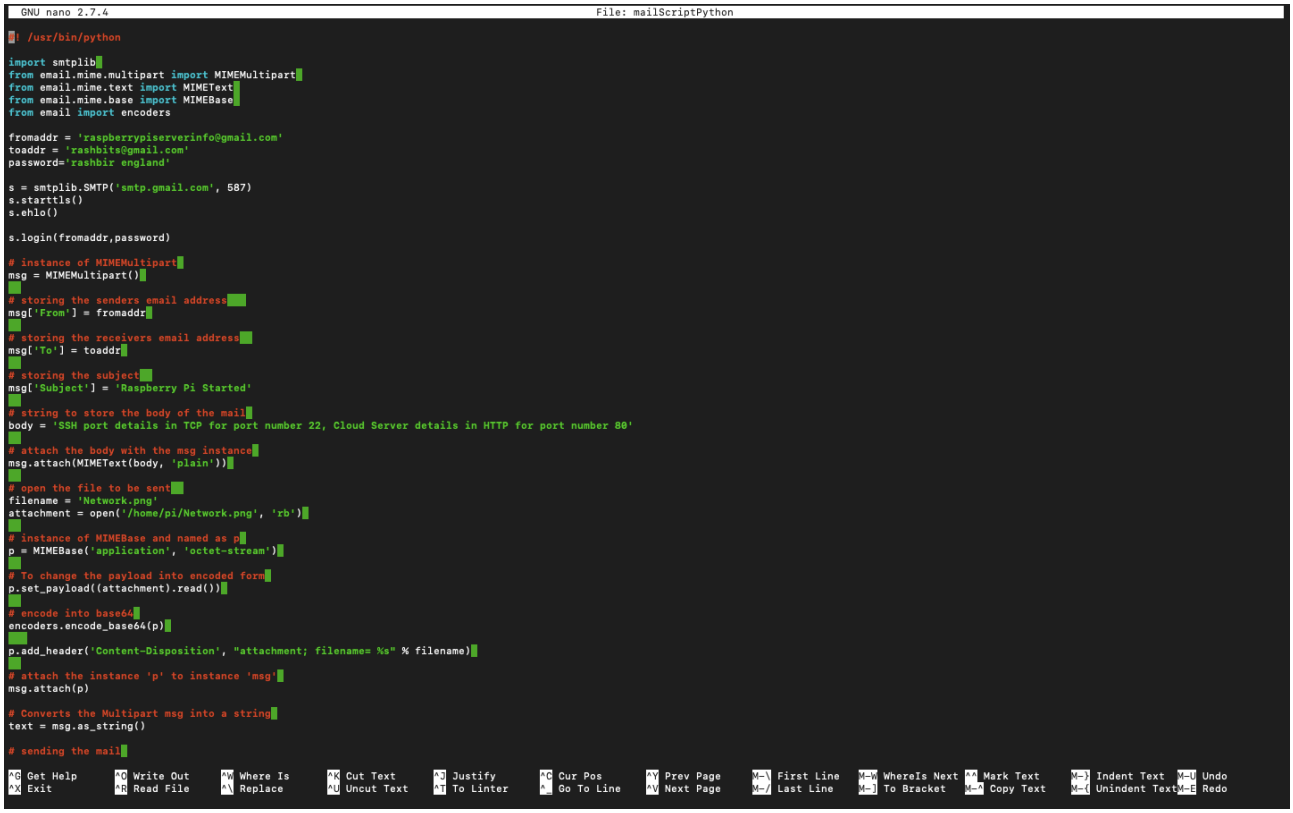

Figure 5.4(a) mailScriptPython

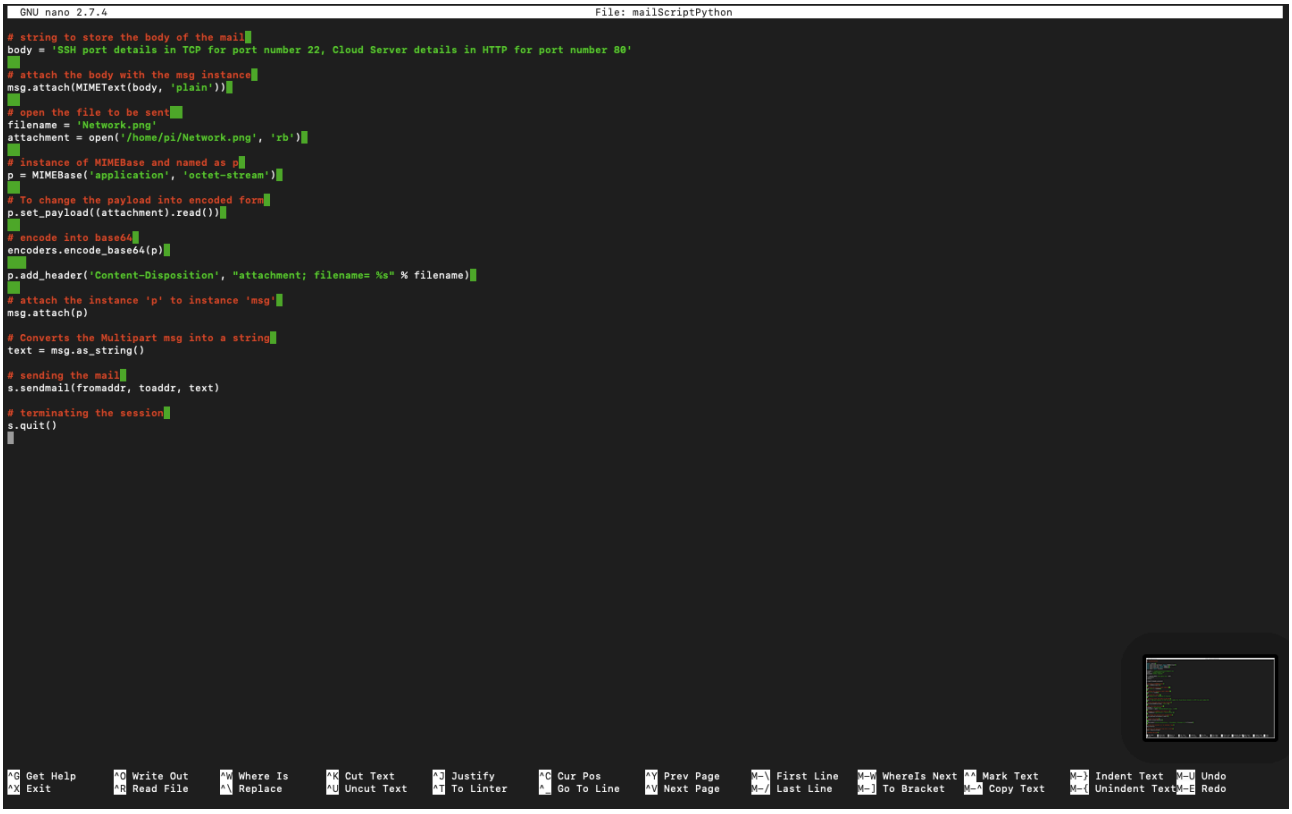

Figure 5.4(b) mailScriptPython

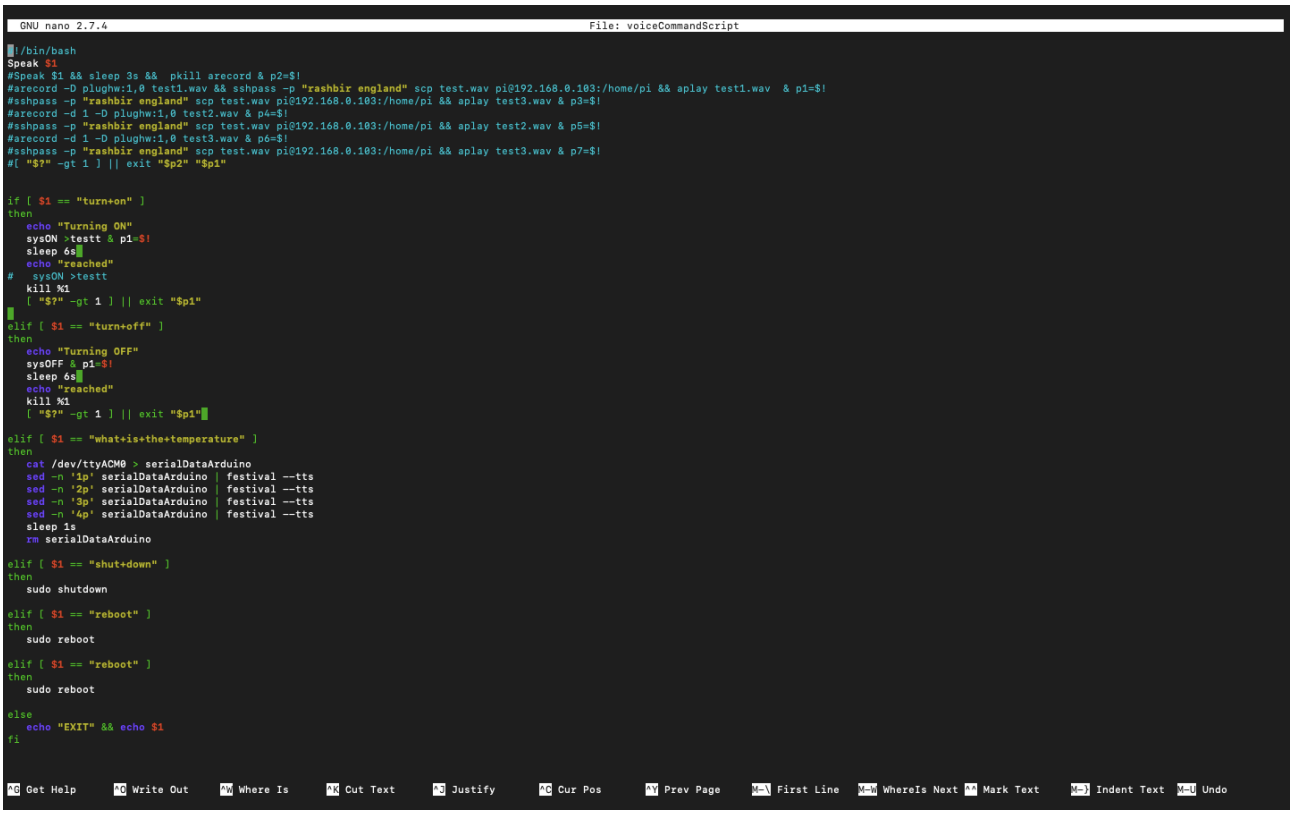

Figure 5.5(a) voiceCommandScript

Figure 5.5(b) Speak

The ngrok uses commands like:

1. ngrok tcp 22
2. ngrok http 80

3. ngrok start –all

The file for configuration is located at /home/pi/.ngrok2/ngrok.yml and is edited using sudo nano and is as shown in figure 5.2

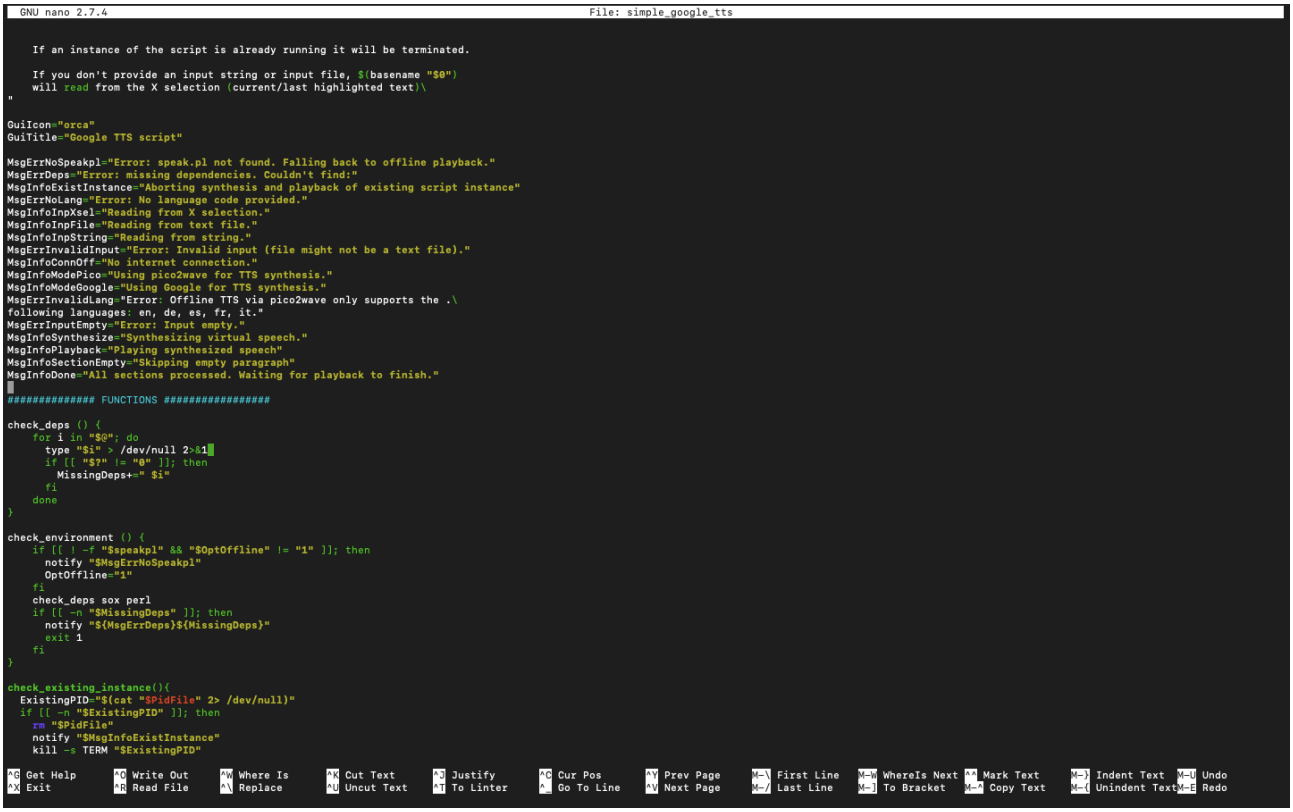

Figure 5.5(c) simple_google_tts

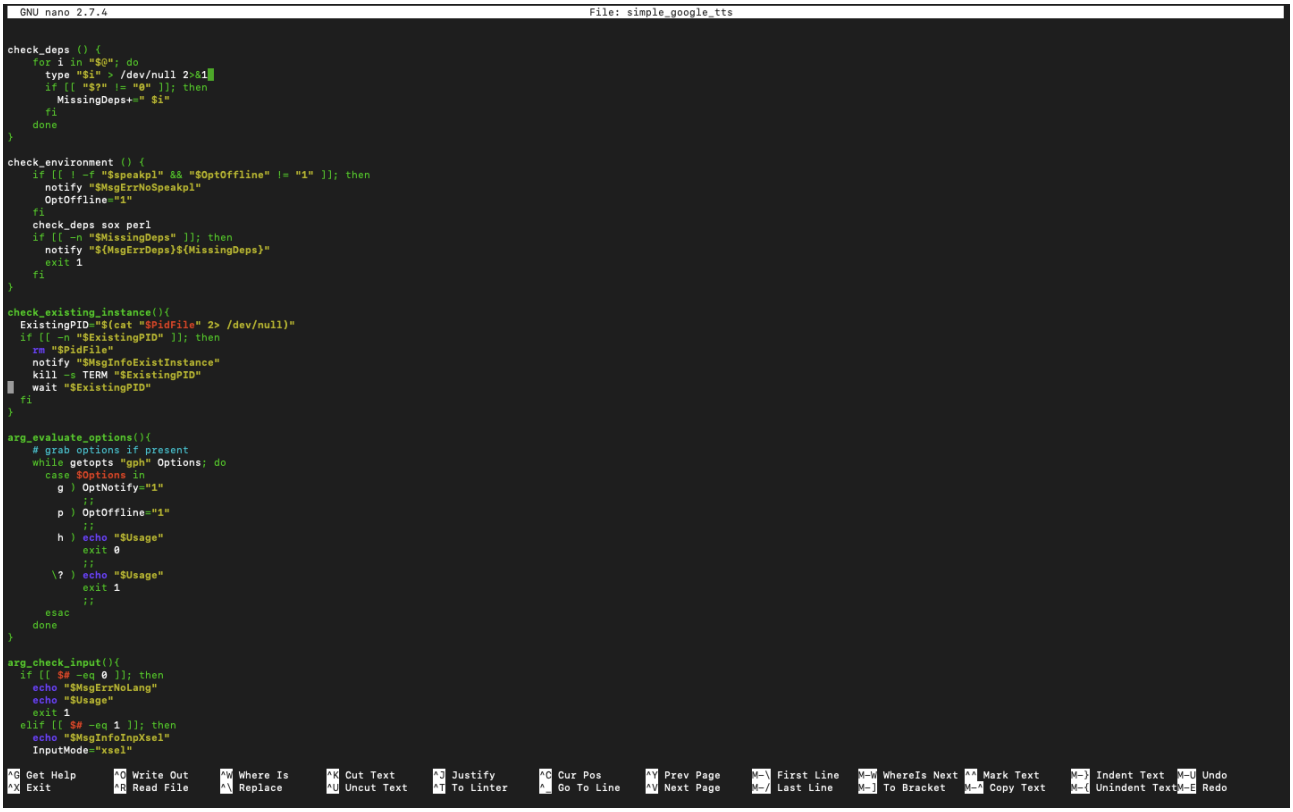

Figure 5.5(d) simple_google_tts

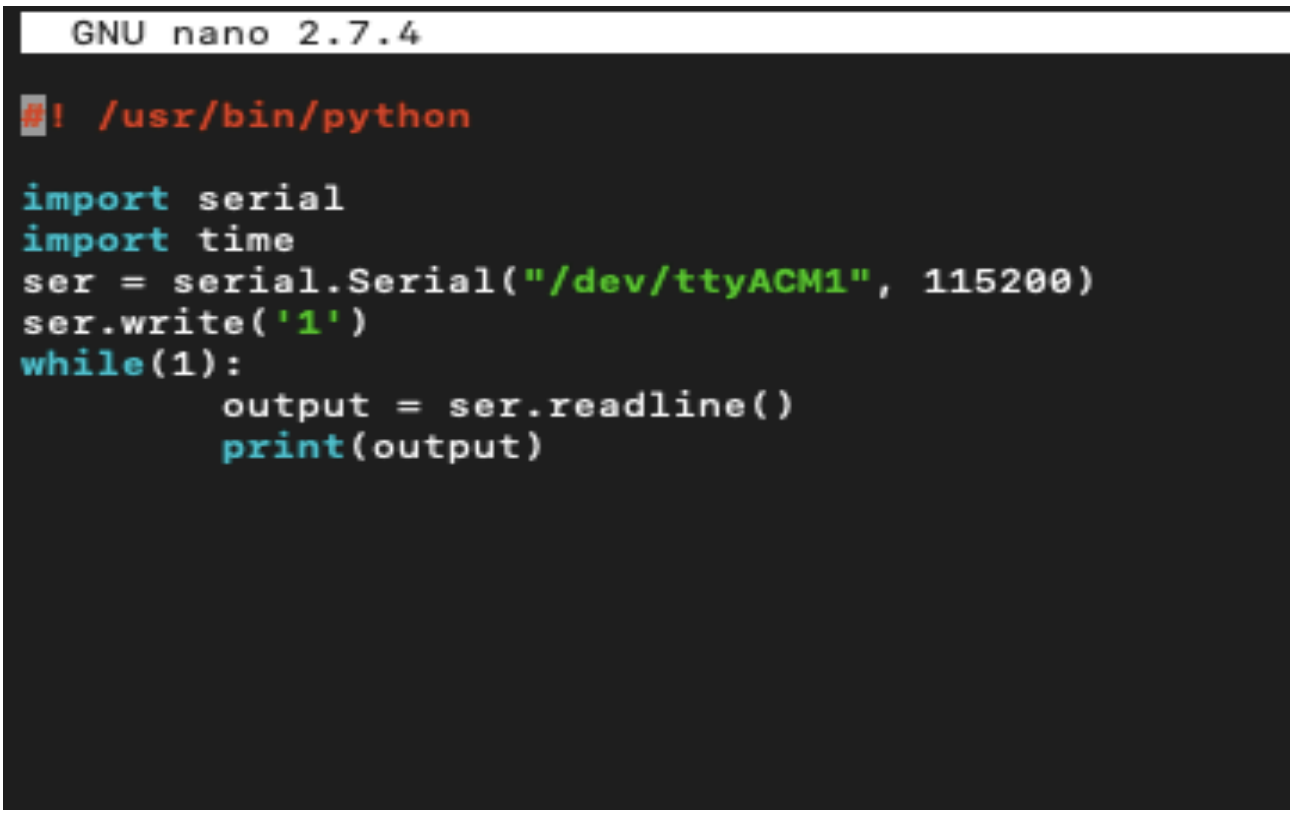

Figure 5.6(a) sysON

CloudScript – This script is saved in bin location and changed mode using 'chmod 755 filename' to executable form so this bash script can easily be executed using a single command called cloudScripts. This command called 'cloudScript' is then saved into the 'bashrc' file, using command 'nano ~/.bashrc'. So this makes the cloudScript to run by default as soon as the terminal opens. Now the terminal is made to open by default as soon as the server starts and login into the operating system.

The cloudScript looks like as shown in figure 5.3:

1. First the script is converted to a bash file so the terminal can know that it is an executable type of file. This is done by using #!/bin/bash
2. a file variable is created with the location of a file in it called cloudScript.temp which is a temporary file that prevents the re-execution of the cloudScript so only one instance creates for a session.
3. Later that file is tested using if-then else condition for the existence of the file.
4. If file do not exist then a file is existed and a line is echoed saying "[WARNING] ngrok Instance created, Please do not delete it.
5. And the programs wait for creation by sleeping for 2 seconds.
6. Then method of parallel exicution of command is used using & p(n) = $(n), where (n) is an integer number matching the number of command and later the execution is killed using **["$?" -gt 1] || exit "$p(n)" .**
7. Screen short is taken using 'import -window root filenage.png' and saved in a location.
8. That screen short is then mailed using the script created in python to the specified email address telling the ngrok instance address so that can be accessed using web browser or the terminal to ssh in the remote machine.
9. The mailing script developed in python is shown in figure 5.4(a) and 5.4(b).

```
  GNU nano 2.7.4

#! /usr/bin/python

import serial
ser = serial.Serial("/dev/ttyACM1", 115200)
ser.write('0')
while(1):
        output = ser.readline()
        print(output)
```

Figure 5.6(b) sysOFF

```
  GNU nano 2.7.4

#! /usr/bin/python

import serial
import time
ser = serial.Serial("/dev/ttyACM1", 115200)
while(1):
        output = ser.readline()
        print(output)
```

Figure 5.6(c) sysSTAT

10. Another script called RebootScript is created which whose only motive is to remove the png screen capture and the temp file of cloudScript so a new ngrok instance can be created.

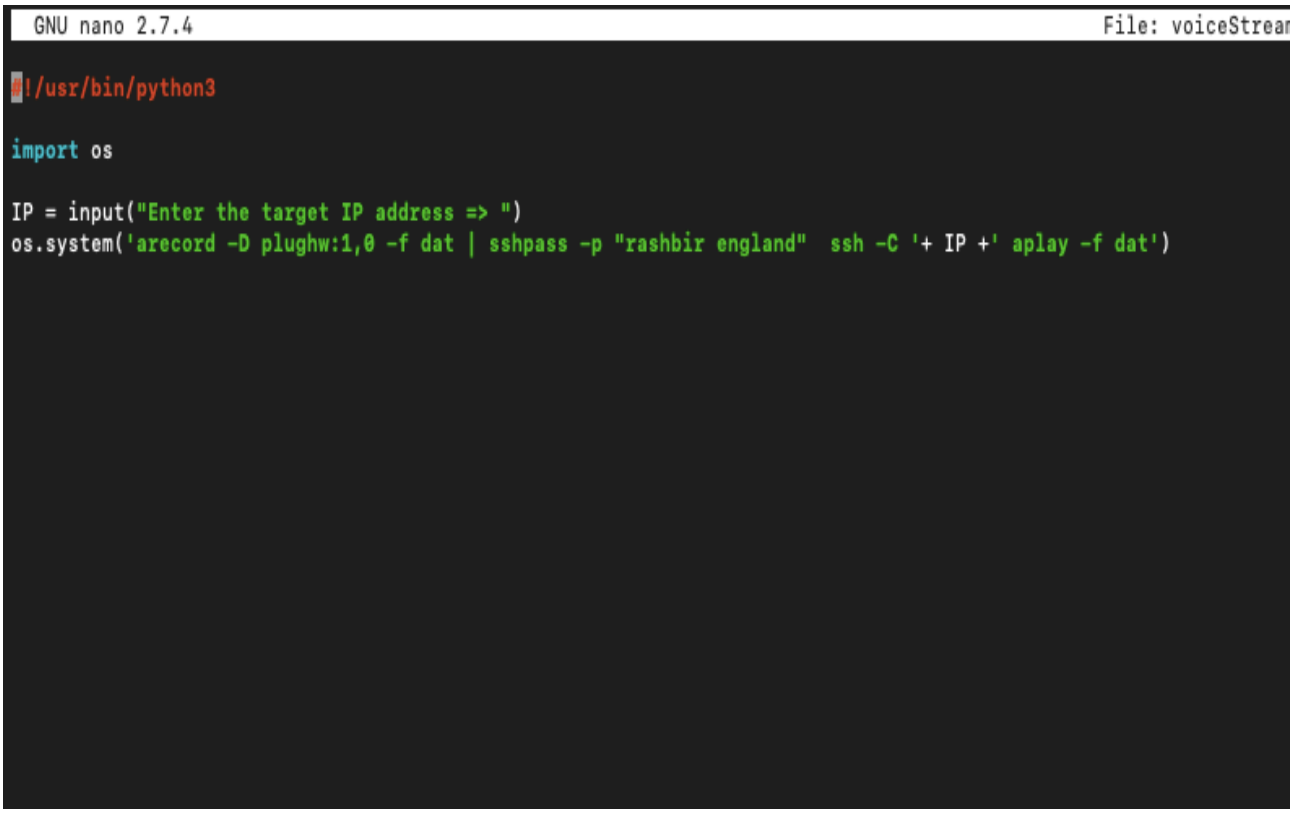

Figure 5.7 voiceStream script

11. This file is then made to execute as soon as the os boots and is achieved using 'sudo update-rc.d NameOfTheScript defaults' command in the terminal.
12. Saving the file in init.d allow the script to be controlled using a single turn ON and OFF commands:

    1. sudo /etc/init.d/NameOfTheScript start
    2. sudo /etc/init.d/NameOfTheScript start

13. This helps in making the robust and smart and a complete black box which allow a simple power ON and OFF mechanism and the user do not have to worry about what is going inside the server as server manages it self.

TTS – The text to speech conversition is done and commands are executed as programmed. The script for the command can be sheen in :

1. Figure 5.5(a) i.e voiceCommandScript
2. Figure 5.5(b) i.e Speak script
3. 5.5(c), 5.5(d) and 5.5(e) i.e simple_google_tts script

All the scripts combined support the architecture of text to speech conversion executing the commands based on the received text and communication with the client and server.

Bash Scripts – This part is consist of many scripts like:

1. sysON
2. sysOFF

3. sysSTAT
4. and counting

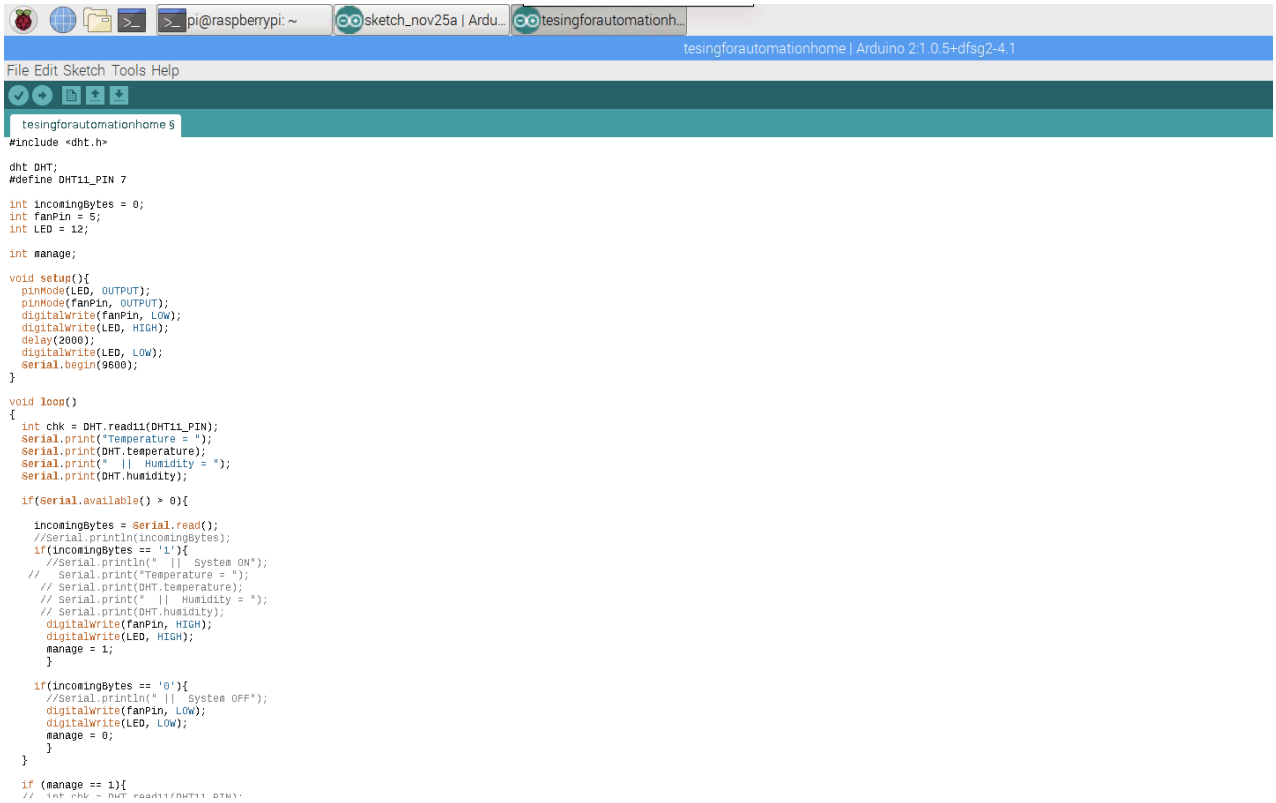

Figure 5.8(a) Arduino Code

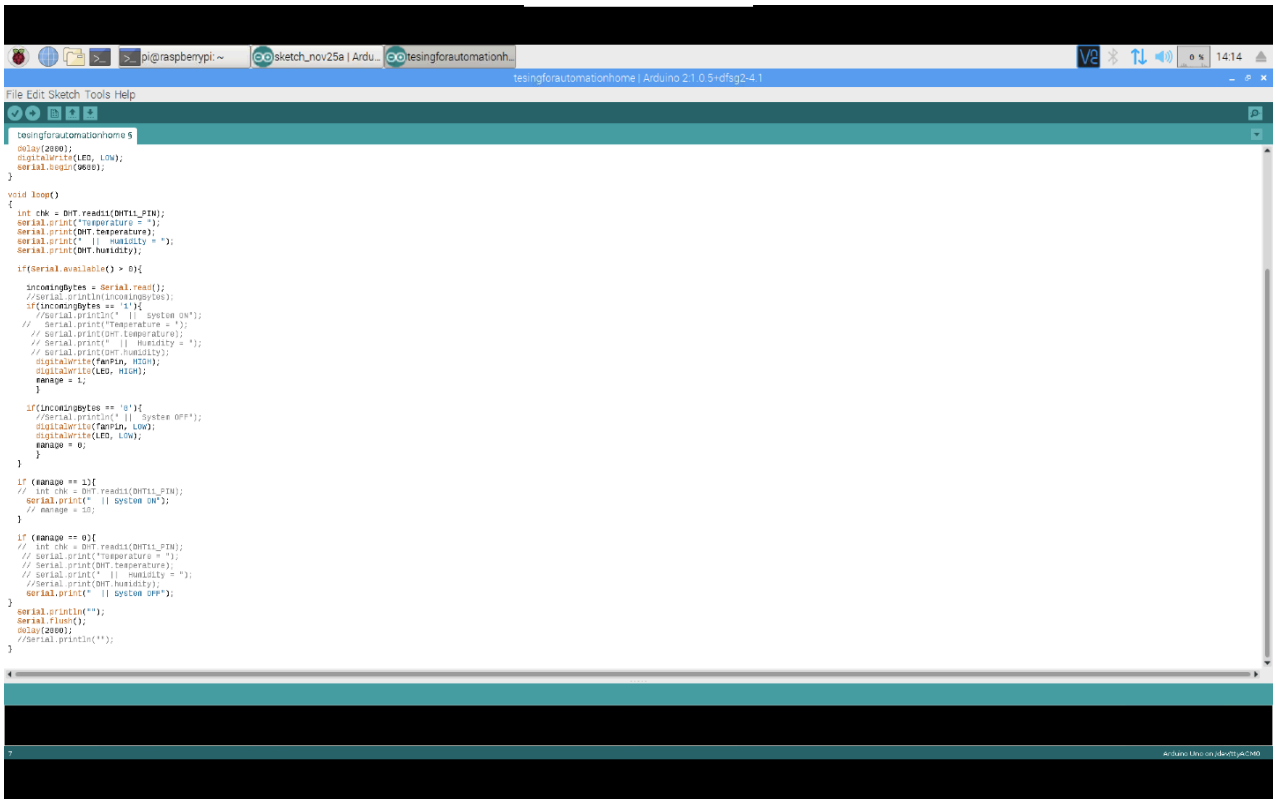

Figure 5.8(b) Arduino Code

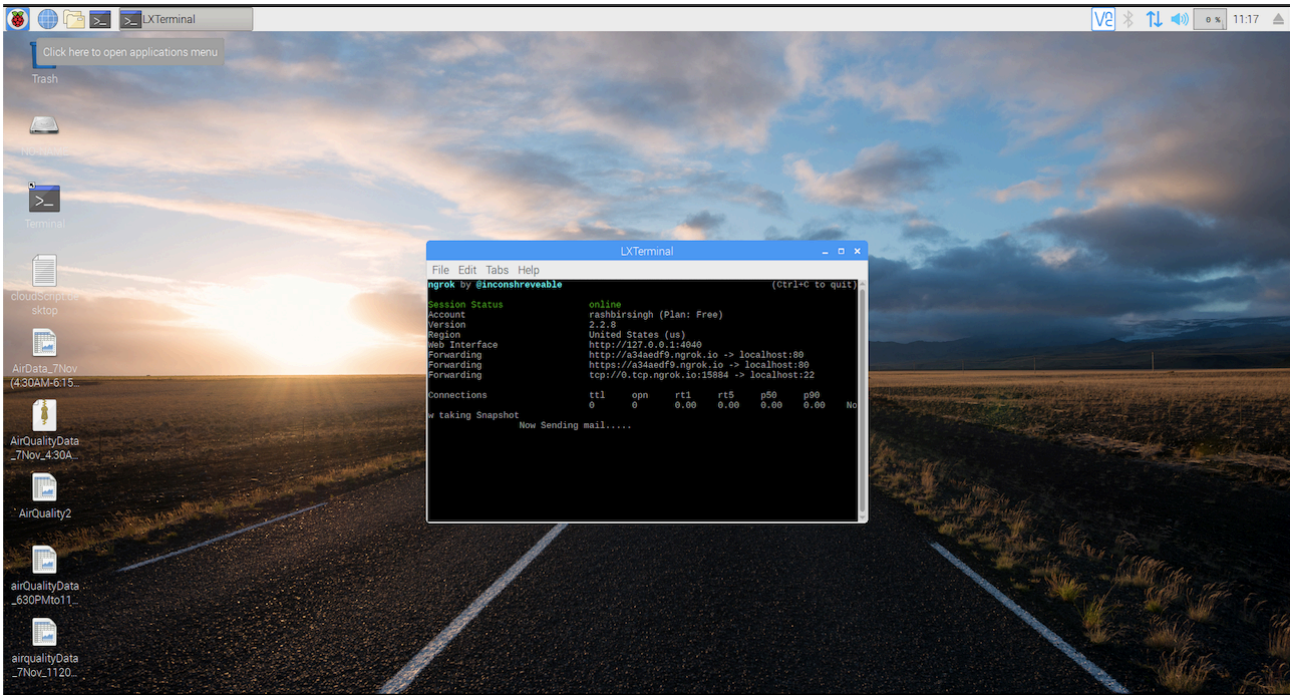

Figure 5.9 Network.png

All the scripts in this component are self build and have different intentions, command converted from speech to text is used and that text is matched with the respective script so as the script can easily be executed just with a voice either inside the local area network or outside using the port forwarded by the ngrok in WAN environment.

The sample scripts for:

1. sysON is shown in figure 5.6(a).
2. sysOFF is shown in figure 5.6(b).
3. sysSTAT is shown in figure 5.6(c).

Application Control – The motive of sysON is to communicate with arduino using serial communication and send commands to execute the respective outcome. Hence supporting the IoT technology and using relays to control appliance connected to the high voltage input coming directly from the power socket.

VoiceStream script – The motive of this script is to stream the input from the microphone from the server to the target i.e client device and is achieved using commands like ‘arecord’ and ‘aplay’. Which helps is recording the sound and play it directly to the remote client as a live stream in real time, this helps in transfer of the spoken TTS(Text to speech) by the servers speaker which are attached to it using a 3.5MM jack wire.

The command is **‘arecord -D plughw:1,0 -f dat | sshpass -p "rashbir england" ssh -C '+ IP +' aplay -f dat’.**

The script is made executable using same ‘chmode 755 filename’ command and the first line is added with’#!/usr/bin/python3’ which helps the terminal to recognise that the following script requires to be run in python 3 environment.

Hence the python code is used to design the script and os library is imported and os.system(‘terminal command’) is used to execute the terminal command in python environment.

Figure 5.7 shows the voiceScript designed on OS and running on OS.

Microcontroller program – This is the hard coded program uploaded on microcontroller to use its microprocessor to process the hard coded program uploaded to its memory. Here arduino uno is used and the code uploaded is shown in figure 5.8(a) and 5.8(b).

Finally figure 5.9 shows the received screen capture in the email that shows the ngrok domain name allocated and ssh port that can be accessed.

The best thing about it is that it always changes, hence providing high security in case of domain leak the server will not be affected as it will reset the domain name. File image here received is called Network.png.

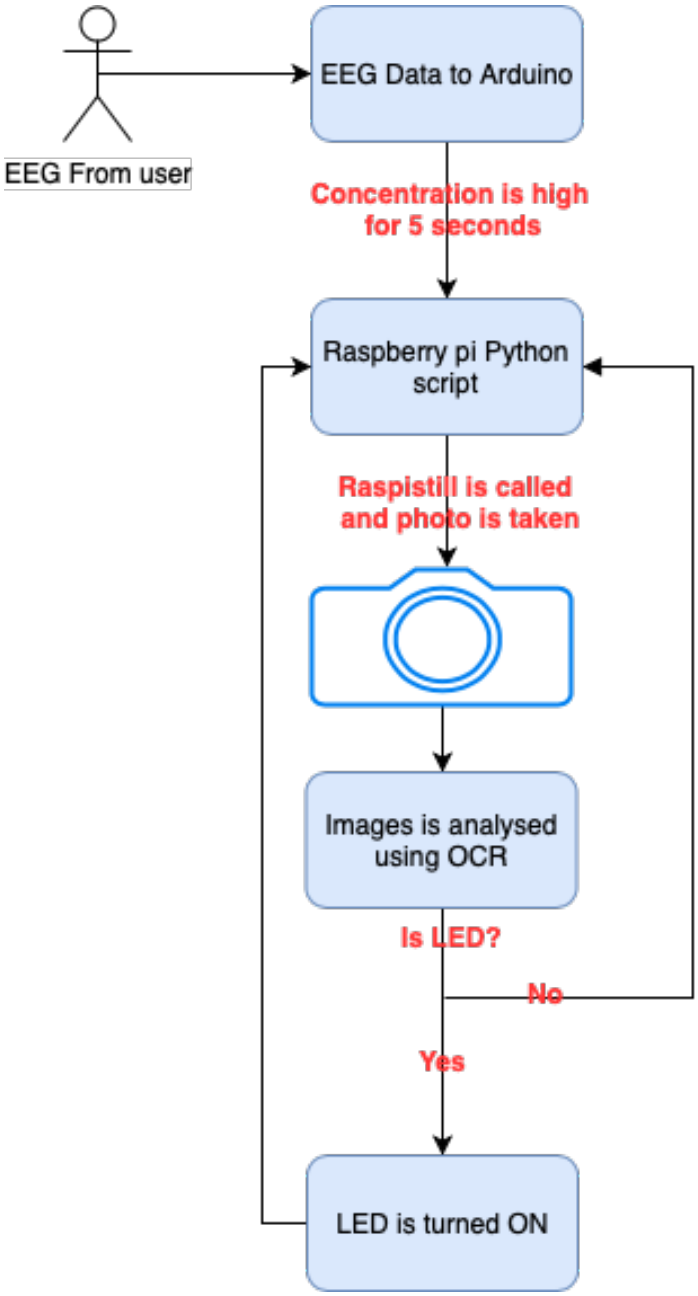

Figure 6.1 methodology for Mind Controlled appliances

Figure 6.1 shows the methodology used to develop a device to provide people with ability to turn appliances ON and OFF just by concentrating on the specific appliance.

The technology used here is Bluetooth to transfer brainwaves over bluetooth to the Arduino micro-controller from EEG. Then the raw brainwaves are converted to numerical format and if concentration is more than the specified than it sends a trigger to the raspberry pi over GPIOs which then triggers a python script.

The script analyse if the concentration to a specific object is more than 5 seconds than the raspberry pi runs a script to take picture of the object which then is analysed by the OCR running with the help of openCV in python environment.

If the text says LED then it triggers and supply the power to the LED, hence result in turning the LED on. If the text is not LED then the scripts run again and stay in a constant loop.

Chapter 7 - Mind Control Setup

This chapter describes the steps followed in order to achieve the mind controlled application by interfacing an Arduino running the raw EEG data converter to a raspberry pi running the OpenCV text detection and image to text converter using the tesseract library.

Tools used are:

1. Arduino IDE
2. Python IDE

Libraries used are:

1. Pytesseract
2. CV2 (OpenCV)

Hardware devices that are used are:

1. Arduino Uno
2. HC-05
3. Neurosky Mindwave
4. Raspberry Pi
5. Raspberry Pi camera
6. LEDs

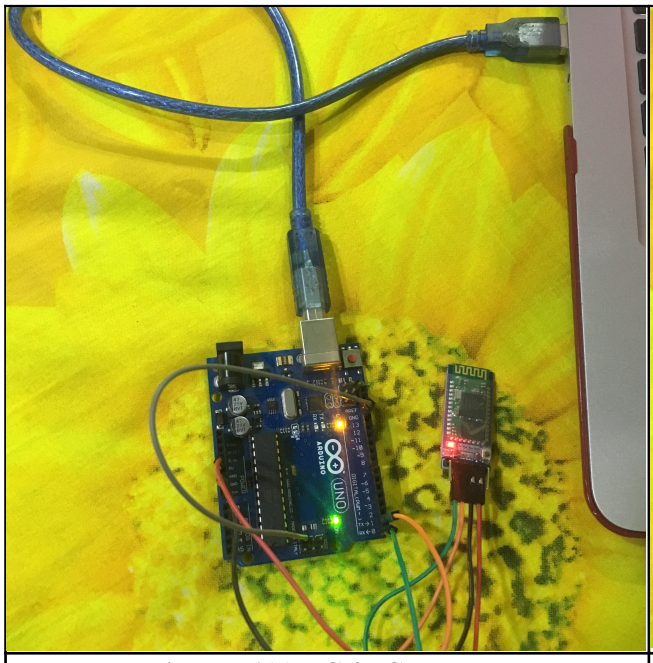

Figure 7.1(a) HC-05 Connected

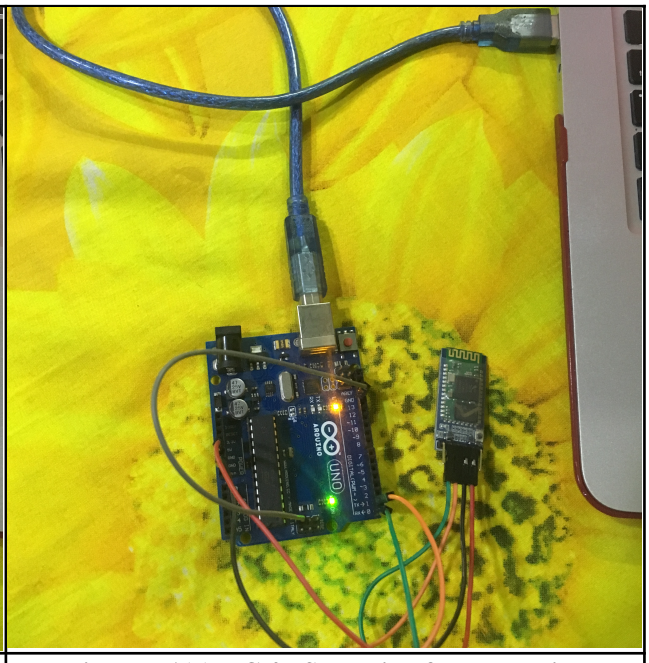

Figure 7.1(b) HC-05 Searching for connection

Steps followed for this are as follow:

1. Attaching HC-05 to the Arduino that will communicate with the Neurosky Mindwave over 57600 baud rate.

2. Writing the embedded C code that will be deployed to the Arduino Uno.
3. Attaching Arduino pins with the raspberry pi so as to send the trigger.
4. Turn ON the camera attached to the pi when a trigger is received by the Arduino Uno and Capture the image.
5. The captured image is being processed for text analysis using Pytessetact

Step 1: HC-05 which is an BLE hardware device that can be connected to any micro controller inorder to communicate with connected bluetooth devices over 57600 baud rate. Figure 7.1 show the HC-05 connected to the Arudino device. Figure 7.1(a) show the HC-05 connected to the Neurosky Mindwave headgear whereas figure 7.1(b) shows the bluetooth HC-05 which is trying to connect to the Neurosky mind wave.

Bluetooth HC-05 is operated in a master mode, i.e the HC-05 will connect automatically to the Neurosky Mindwave headgear as soon as it turn on. It will search for the unique device ID of the Neurosky mind wave and only connects to it, if the Neurosky Mindwave is not found then the bluetooth HC-05 will remain in IDLE mode and will not connect to any other device.

In order to specify this master mode in HC-05 the bluetooth should be configured using AT commands, and figure 7.3 show the setup done using the AT commands so as to configure the bluetooth into master mode.

So, in order to use AT command HC-05 should be connected as per the schematics shown in figure 7.2. Table 7.1 defines what pines of HC-05 should be connected to Arduino uno.

Table 7.1 Connecting HC-05 to Arduino Uno

HC-05 Pin	Arduino Pin
VCC	5Vs
GND	GND
Tx	Tx
Rx	Rx
	ICSP (Reset) — GND

After connecting the HC-05 to Arduino Uno as per the schematics launch Arduino IDE and connect the Arduino Uno via USB 3.0 cable to the PC. Then go to tools and select serial monitor. The serial monitor should launch and we can use it to communicate to Arduino Uno using the serial port. The serial monitor have a field where we can send commands. Figure 7.3 shows the window for serial monitor.

The commands are as follow

Type "AT" (without the quotes) on the serial monitor and press enter. if "OK" appears then everything is all right and the module is ready to take command. Now you can change the name of the module, retrieve address or version or even reset to factory settings. To see the default name,

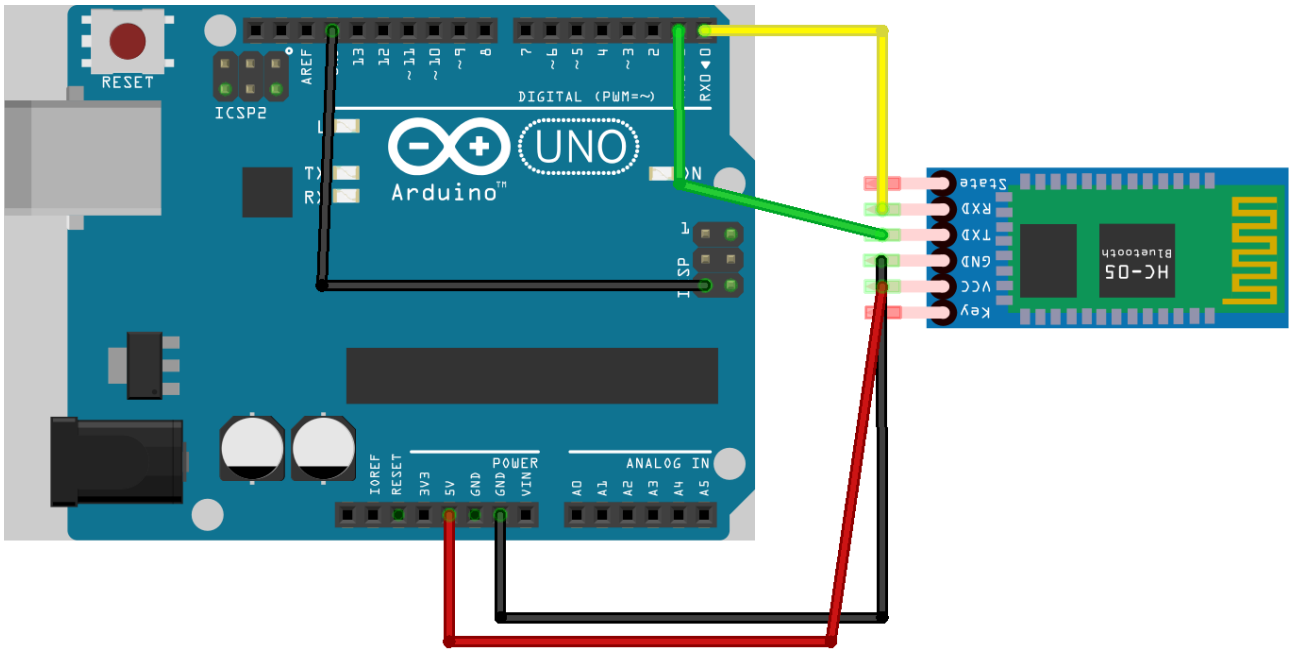

Figure 7.2 Connecting HC-05 to Arduino Uno

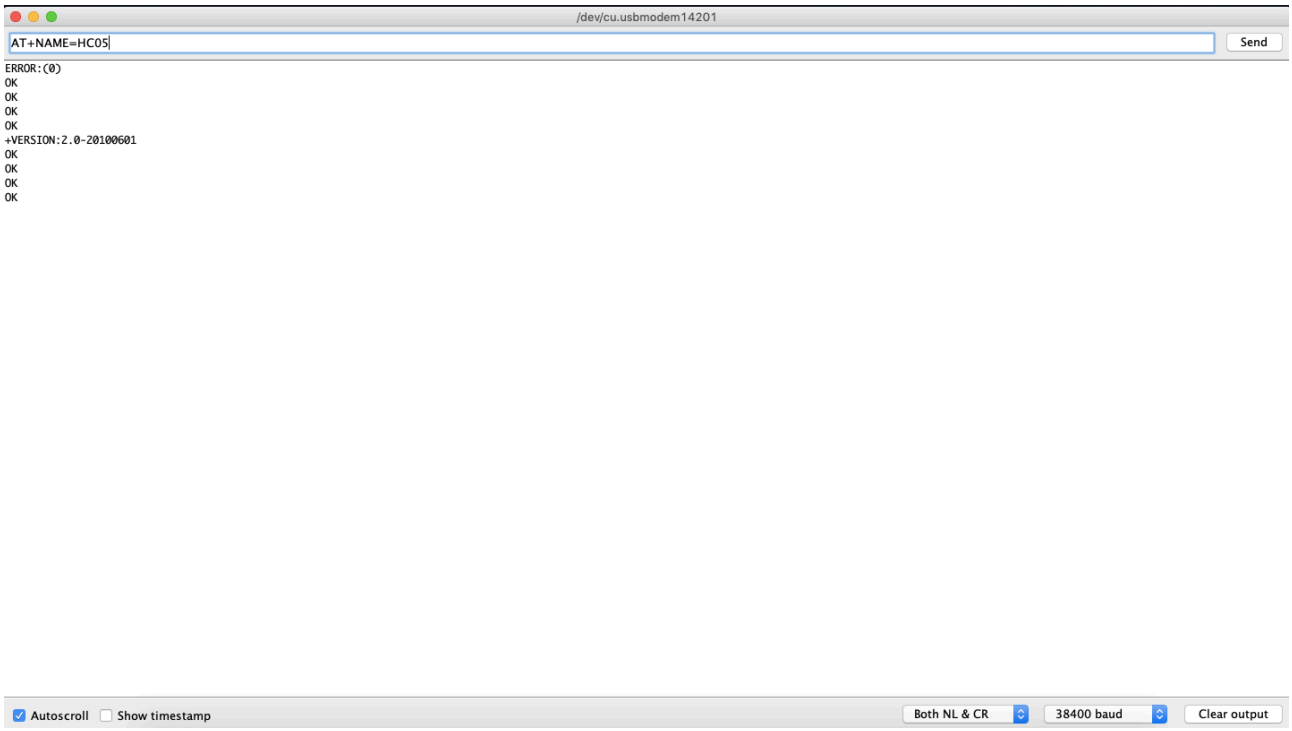

Figure 7.3 Serial monitor

type AT+NAME. The name will be prompted, by default it is HC-05 or JY_MCU or something like that. To change the name just type AT+NAME=your desired name.

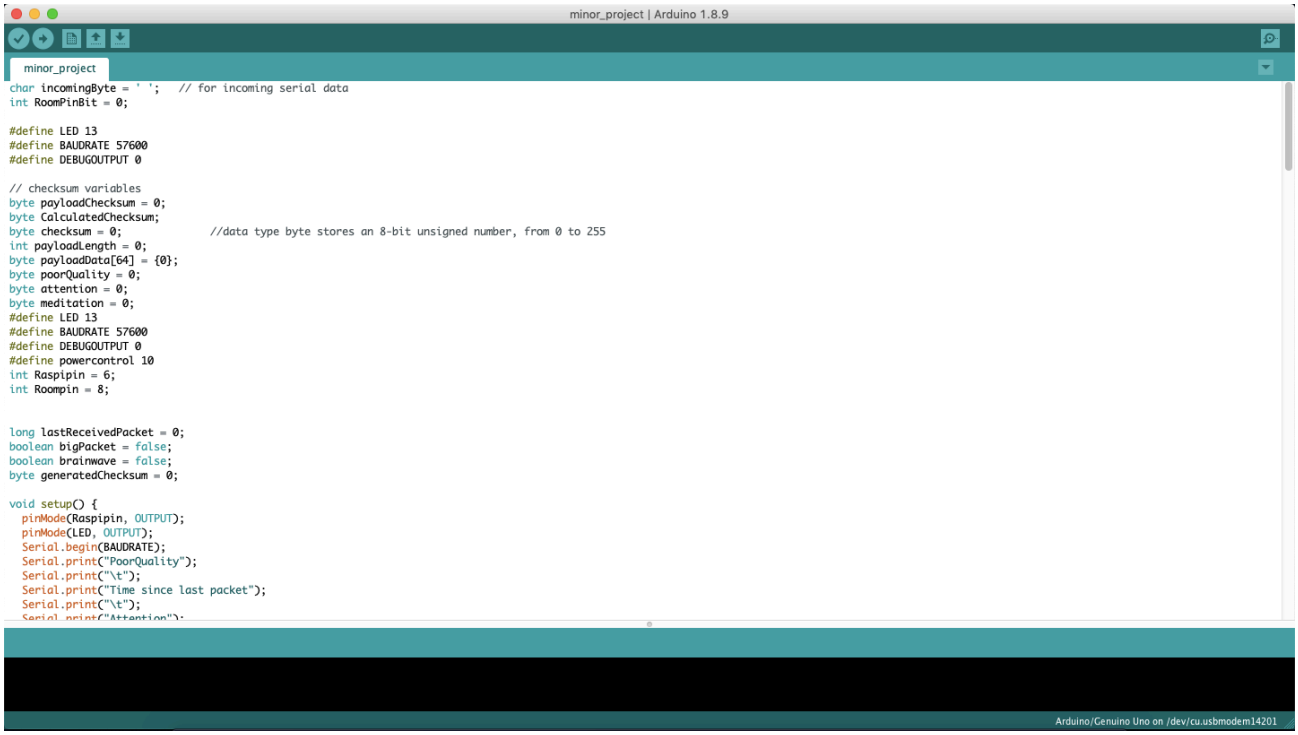

Figure 7.6 Arduino code

Here is an important note, if the key pin is not high, i.e. not connected to Vcc while receiving AT commands(if you did not solder the wire and released it after the module entered AT mode), it will not show the default name even after giving right command. But you can still change the name by the command mentioned above. To verify if the name has really changed, search the device from your pc/mobile. The changed name will appear. To change baud rate, type AT+UART=desired baud rate. Exit by sending AT+RESET command.
Most useful AT commands are

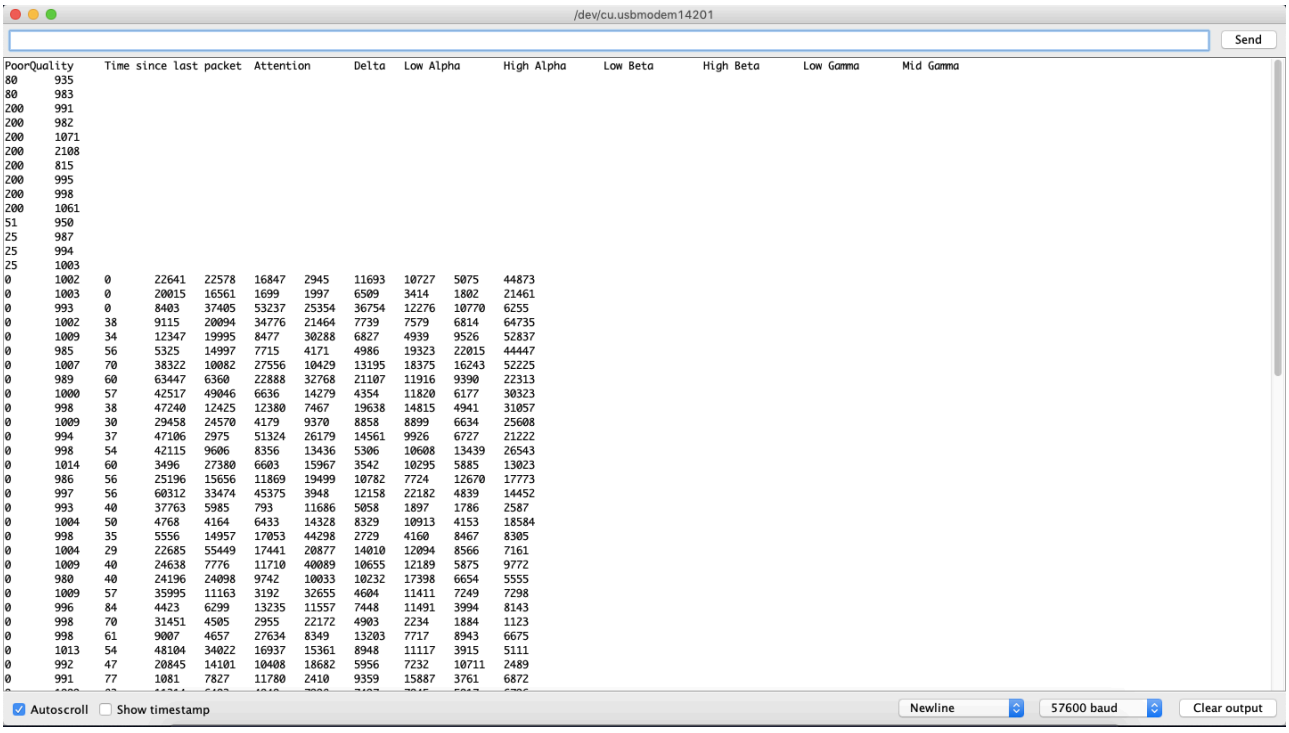

Figure 7.7 Received data

Figure 7.5(a) Neurosky MindWave Turned OFF

Figure 7.5(b) Neurosky MindWave Turned ON

1. AT : Ceck the connection.
2. AT+NAME : See default name
3. AT+ADDR : see default address
4. AT+VERSION : See version
5. AT+UART : See baudrate
6. AT+ROLE: See role of bt module(1=master/0=slave)
7. AT+RESET : Reset and exit AT mode
8. AT+ORGL : Restore factory settings
9. AT+PSWD: see default password
10. AT+BIND: Bind the HC-05 to the specified ID

Figure 7.4 shows the commands sent inorder to configure the HC-05

Step2: After the HC-05 is setup into master mode, now it is time to write code inorder to make a raw EEG to labeled brain wave data into numerical form. Figure7.5(a) shows the turned OFF EEG head gear(i.e Neurosky Mindwave) and figute 7.5(b) shows the turned ON EEG headgear.

Neurosky Mindwave technology allows for low-cost EEG-linked research and products by using inexpensive dry sensors; older EEGs require the application of a conductive gel between the sensors and the head. The systems also include built-in electrical “noise” reduction software/ hardware, and utilize embedded (chip level) solutions for signal processing and output.

The human brain is made up of billions of interconnected neurons; the patterns of interaction between these neurons are represented as thoughts and emotional states. Every

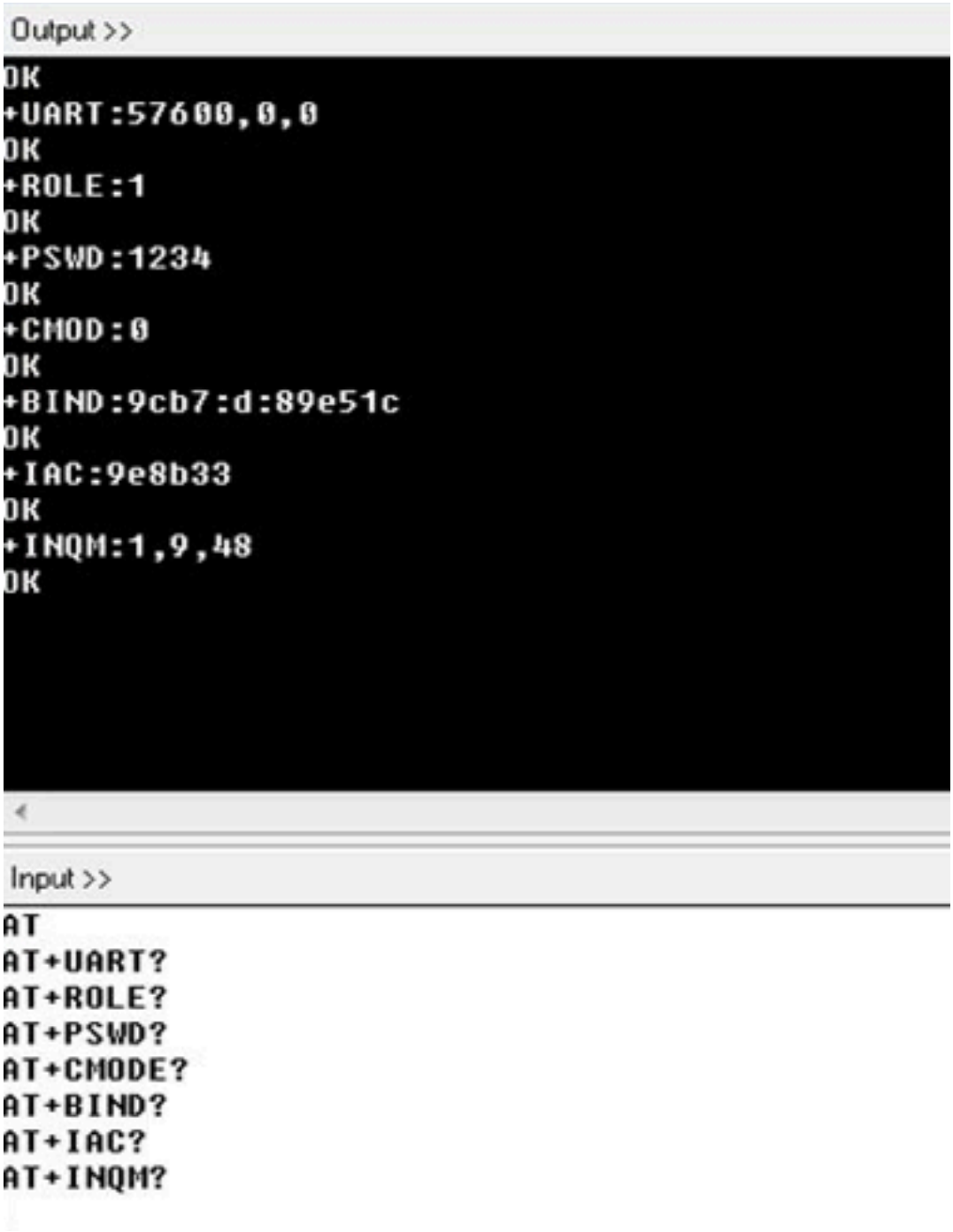

Figure 7.4 Hc-05 setup

interaction between neurons creates a minuscule electrical discharge; alone these charges are impossible to measure from outside the skull. However, the activity created by hundreds of thousands concurrent discharges aggregates into waves which can be measured.

Different brain states are the result of different patterns of neural interaction. These patterns lead to waves characterized by different amplitudes and frequencies; for example waves between 12 and 30 hertz, Beta Waves, are associated with concentration while waves between 8 and 12 hertz, Alpha Waves, are associated with relaxation and a state of mental calm. (The contraction of muscles is also associated with unique wave patterns, isolating these patterns is how some NeuroSky devices detect blinks.)

All electrical activity produces these waves (even light bulbs), thus all electrical devices create some level of ambient “noise”; this “noise” interferes with the waves emanating from the brain, this is why most EEG devices will pick up readings even if they are not on a person's head. Measuring mental activity through these waves is like trying to eavesdrop on a conversation at a loud concert. In the past, EEG devices circumvented this problem by measuring these signals in environments where electrical activity is strictly controlled and increasing the signal strength of the data coming from the brain through the application of a conductive solution.

However, most people don’t have rooms in their house devoid of electronic devices nor do they want to apply a conductive liquid to their head every time they use a BCI device. NeuroSky has developed complex algorithms built into their products which filter out this “noise”.[7] NeuroSky's white paper claims the ThinkGear technology has been tested at 96% as accurate as that within research grade EEGs. NeuroSky is also selling non-contact sensors to research institutions. These are dry electrodes that can measure brainwaves millimeters from the scalp and thus can easily be worn over hair. These sensors are a significant technological breakthrough in that they are the only non-contact EEG sensors ever developed.

Figure 7.6 shows the Code developed onto the arduino, that recieves the raw EEG data from its HC-05 module that is connected to Neurosky indwave over BLE. Hence the developed code shows the following result as shown in figure 7.7 and following columns Ade created i.e

1. Poor Quality
2. Time since
3. Last packet
4. Attention
5. Delta
6. Low Alpha
7. High Alpha
8. Low Beta
9. High Beta
10. Low Gamma
11. Mid Gamma

Poor Quality - Defines the connection quality, ranges from 0 to 200, where 200 is the worst connection and 0 is the best. So, the algorithm is designed in such a way that when the poor quality is 0 only then Arduino will receive data that is sent by the EEG headgear. Hence ensuring the maximum accuracy.

Time Since - It gives data related to the time of receiving.

Attention - It gives the users attention level.

Brainwaves - These are the waves generated in an electromagnetic fashion by our brain. Which are categorised into five categories, alpha, beta, theta, gamma and delta while EEG is the technology used to capture the electric potential differences generated inside ones brain and read these brain waves which then can be used for analysis of treatment in medical fields. In this research work we used this for analysing different mental and physical state with the help of data mining.

EEG - An electroencephalogram (EEG) is used to discover inconveniences related to an electric movement of the brain. An EEG tracks and insights and mind wave fashion. Little metallic plates (electrodes) with small electric wires are placed above the head of the user, the amplifier amplifies the electromagnetic brain waves, captures it and plot a real-time graph of the electric movements inside the brain. The graph shows us the events and impacts happened inside the brain. A person's day-to-day activity and his interest creates an electric brainwave into a recognizable patter. Through an EEG, Therapeutic specialists can scan and anticipate the seizures and different issues. He/she will give you the recommendation changes in lifestyle/medication to help the person.

Alpha - Alpha brain waves are in range of 8-13 HZ reference. They are also categorized as Berger's wave in memory of the originator of EEG. Alpha waves are unique kind of brain waves. It is noticed that electric potential of alpha waves increases which can be recorded by electroencephalography (EEG) or Magnetoencephalography (MEG). These waves are originated from the occipital lobe of brain as soon as a person begins to gain relaxation with his eyes closed while staying awake. The alpha waves have following features: -

Every activity requires the involvement of these waves. So, by this, it is noticed that different activities comprise of different frequency requirements like waves generated during movement of arm will be different than that of movement of legs, or when a person is meditating or listing to music. These waves reduced when a physical movement occurs or the intention of movement takes place.

Beta - Beta brainwaves varies from 13 Hz — 20 Hz spectrum. Beta electric waves in brain neurons is the highest frequency brainwaves which are generated when we feel attentive, focused, and have high intensity of alertness. Lack in these brainwaves are often related to problem of attention level, the person faces difficulty in carrying on a certain task for longer consecutive period of time, disability in learning and injured brain cells. The brain mapping of ASD patients has also been exposed to the fact that patients have both highly fast and slow brainwaves activity in the frontal lobe of the brain, that might suggest lack of interconnection between the frontal lobe and back area of the brain neurons.

1. Low Beta Waves (12.5-16 Hz, "Beta 1 control")
2. Beta Waves (16.5-20 Hz, "Beta 2 quality")
3. Unnecessary Beta Waves/Hi-Beta (20.5-28 Hz, "Beta 3 quality").
4. Beta states are the states which are identified with common waking cognizance.

Gamma - Gamma brainwaves are not similar to gamma radiation waves. Gamma mind waves are the electric brain waves which are generated between the brain neurons that vary between 25 and a 100 Hz, with the cycle of about 40 Hz, this is the normal healthy human being and in general range, it is always >20 Hz.

Theta - The frequency range of theta brain waves varies from 4 Hz - 8 Hz. These waves are often called as "suggestible waves" because of prevalence during the state of trace or hypnotism. Theta brainwaves are unique as they exist between one's sleep and daydreaming which results in making us feel more relaxed with an open mindset. Feeling of raw and deep is often related to theta brainwaves as they are the main reason because of which we are experiencing that. An excessive amount of theta generation exposure may often lead to make people defenseless in some situations

of despairing. Theta brainwaves has its own impact as they are main reason of helping in enhancement of our innovative thinking and impulse which make us feel more natural. It moreover helps with the restoration of sleep from stressful conditions. As long as the time period of theta exposure is large or the volume is high, it is much helpful for our brain and overall personality.

EEG uses distinct brainwave (delta, theta, alpha, beta, gamma) are generated by different parts of the brain for detecting distinct emotional spectrum like stress, small muscle movements, feeling of joy, sadness, relaxation, the wink of the eye, movement of the neck, level of attention, mediation a person has, and so forth. Different researches use distinct brainwaves combination to prove their studies.

Table 7.2. EEG information and their ranges

Waves	**Frequency**	**Short Definition**
Alpha	8–13 Hz	Alpha brainwaves delivers a trademark quiet, inventive, 'sense redress' state while we close to our eyes and start to pull back from outside tactile incitement. It's the scaffold amongst waking and sleeping.
Beta	13–20 Hz	Beta brainwaves come into place dominate our customary waking cycle of attention. Beta waves are 'quick' generated in an activity, like when we are attentive, alert, occupied with inconvenience tackling, judgment, decision making, or concentrating on our mental hobby. Beta brainwaves are additionally isolated into three groups
Lo-Beta/ Beta1	Beta1, 12-15Hz	They are “rapid”, and deep
Beta/Beta2	15-22Hz	Activities with high involvement that makes sense to us
Hi-Beta/ Beta3	22-38Hz	They are said to be the unnecessary beta are generated during activities involving high tension and excitement level.
Theta	4–8 Hz	Theta brainwaves is our scope for picking up information inside, memory, and one’s instinct.Theta brainwaves generate in most when a person is in sleep yet additionally are overwhelming in profound contemplation.
Gamma	20 Hz	It has been associated with better learned working, self-consciousness, selfmanage, issue settling, dialect change in children, memory and loads of components of increased consideration and idea.
Delta	1–4 Hz	Delta brainwaves are created in rest and private reflection. They are mild, low recurrence and profoundly entering just like a drum beat.

Step 3: For the communication between the arduino and the raspberry pi, arduino PWM and Raspberry pi's GPIO pins are used. The data related to ones brain is collected inside the arduino and once the value of attention is above the specified level then it will send the trigger for specified duration and once the threshold is reached it will send a trigger, see step four.

Connection done is shown is figure 7.8.

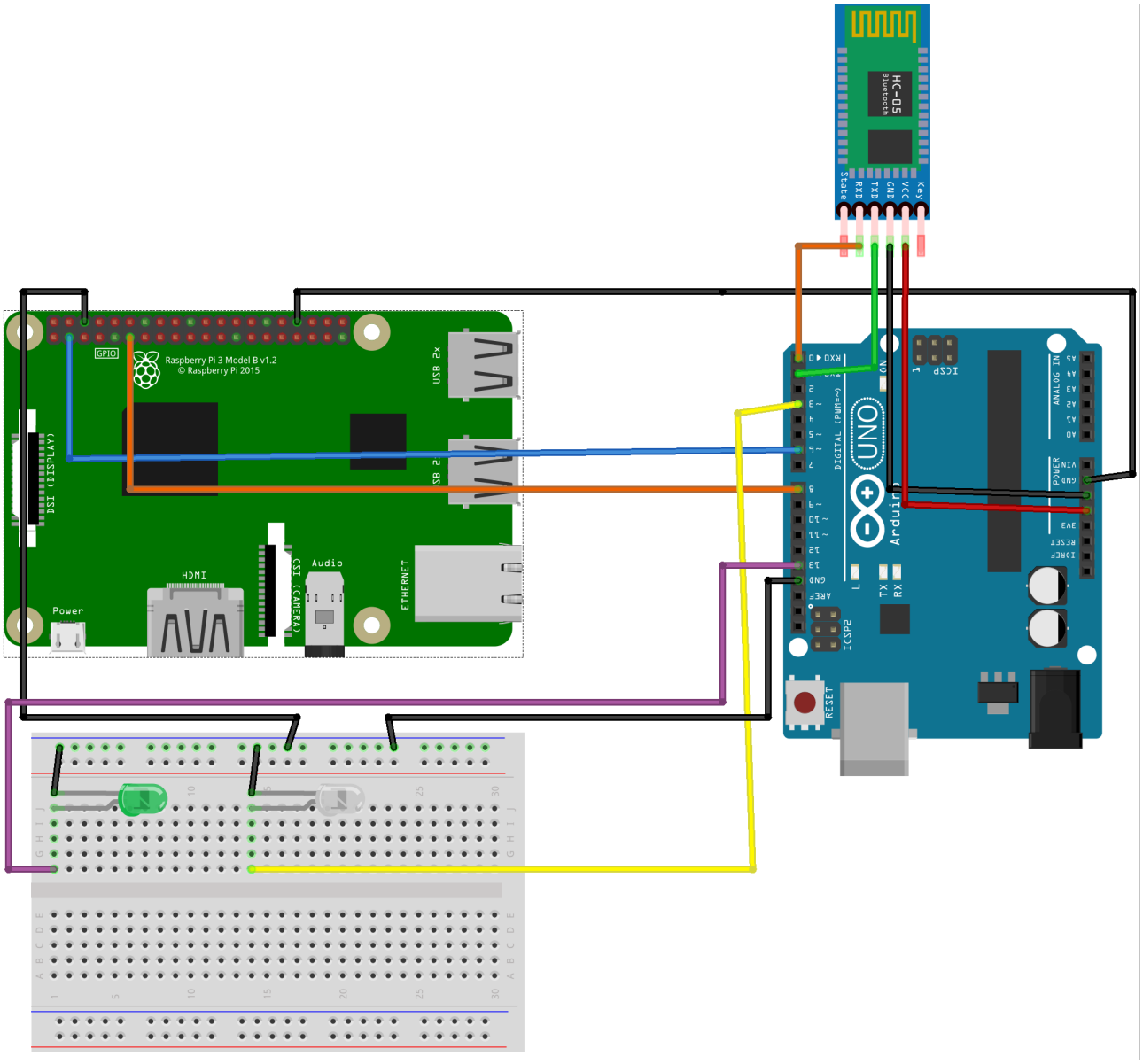

Figure 7.8 Main Circuit diagram connecting Arduino, HC-05 and Raspberry pi with infrared transmitter LED.

Step 4 and Step 5: The raspberry pi is sunning an python script locally that detect the attention level of the brain and once the threshold is achieved it will turn on the raspberry pi camera that will capture and image.The image is expected to have an written text naming the appliance. The text of the image is then detected and recognised using the OCR.

For the purpose python is used, and libraries that are used are:

1. Pillow
2. Pytesseract
3. Gpiozero
4. CV2

After the appliance text is detected and recognised using the PILLOW, PYTESSERACT and CV2 then GPIOZERO library will be used to use one of the pin of the raspberry pi to send a trigger back to the arduino. Once the arduino receives the trigger it then will send a respective turn ON or turn OFF command related to the device. This command is sent using the IR led.

On the other side there is a IR receiver that will receive the command from the device and hence allowing us to control the device functionality using brainwaves and computer vision.

Connection is done as shown in figure7.9

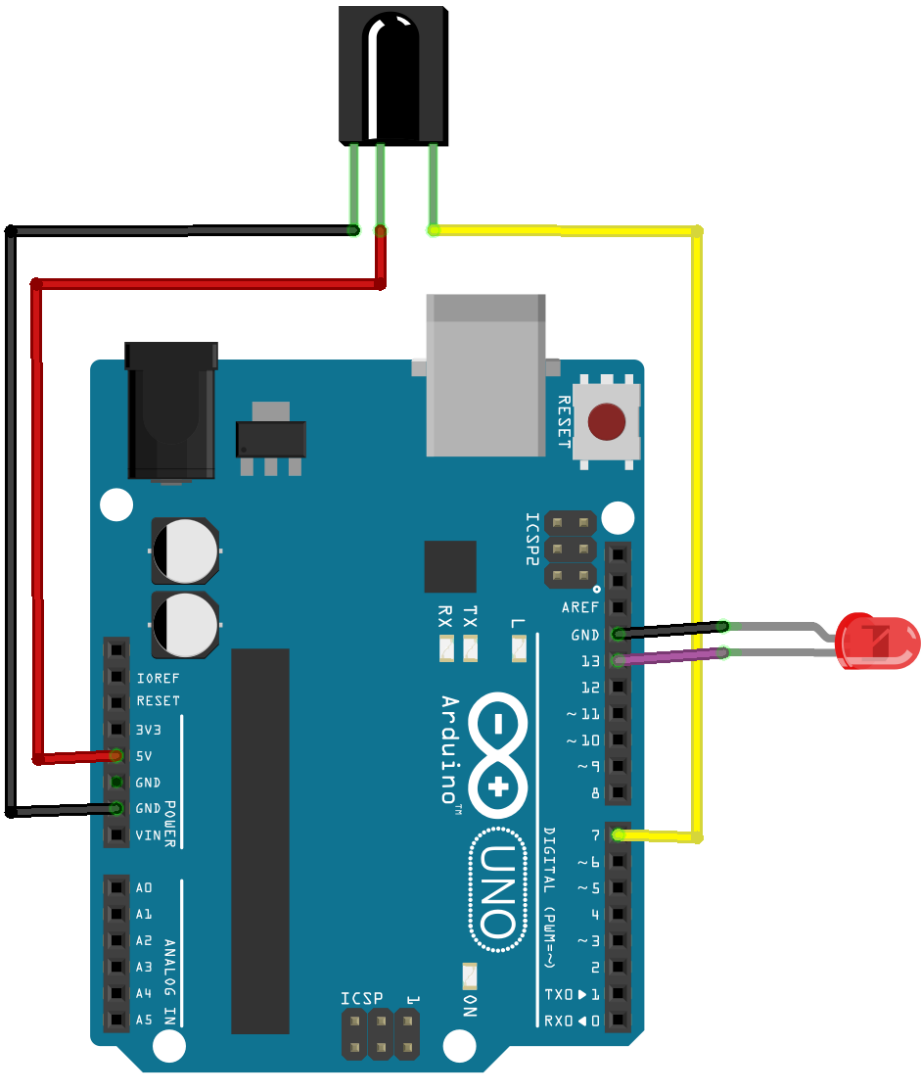

Figure 7.9 Demo for IR receiver to show a practical appliance

Chapter 8 - Conclusion

The developed system is secure, supports cloud server and IoT. Allow the user to control the environments using speech in LAN or WAN environment but also allow the user to control appliance using EEG i.e controlling the environment just by thinking.

It successfully support computer vision and the developed system is robust and affective. Being running so many technologies and inter compatibility, yet it do not require high knowledge of technology and easy to learn for a non tech person. The developed system can be called an affective black box that supports simple command input and output mechanism.

Successfully integrated IR that will be used to control thr appliances. The EEG headgear called neurosky mindwave was able to monitor and calculate persons's attention level and command the device to detect device. As each device uses different turn ON snd turn OFF protocol. This can control various devices with a single command.

It has implementation in field of research, can be used in hospitals, control robots, use to control industrial equipments and can help physically Challenged and deaf people.

Appendix A shows the final complete product for cloud server and Appendix B shows the final complete product for the mind and computer vision controlling device for various appliances.

References

Appendix A

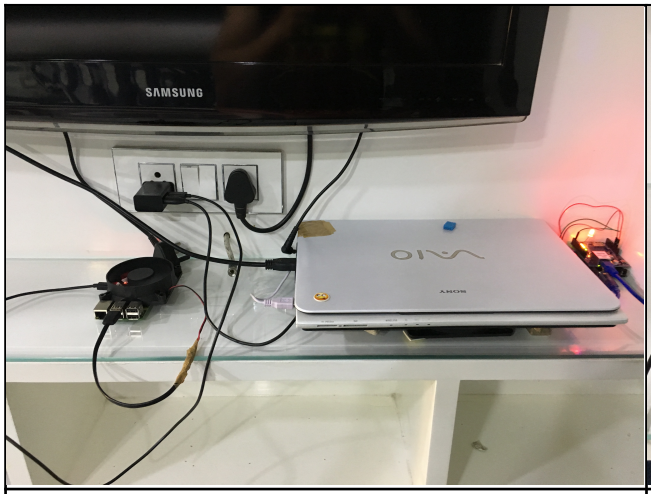

Figure A1. Cloud Setup 1

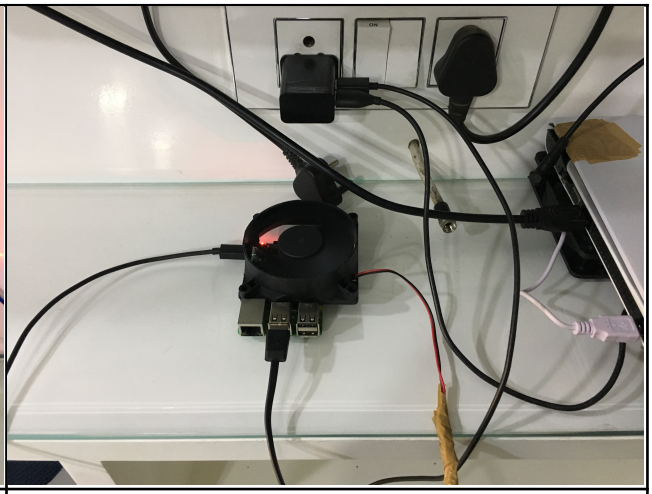

Figure A2. Cloud Setup 2

Figure A3. Cloud Setup 3

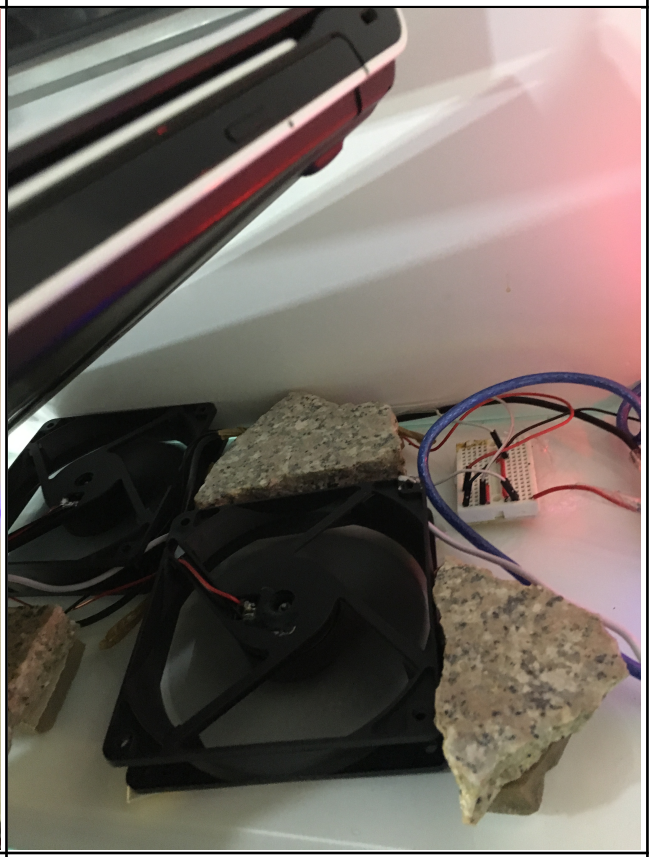

Figure A4. Cloud Setup 4

Figure A5. Cloud Setup 5

Figure A6. Cloud Setup 6

Figure A7. Cloud Setup 7

Figure A8. Cloud Setup 8

Figure A9. Cloud Setup 9

Figure A10. Cloud Setup 10

Appendix B

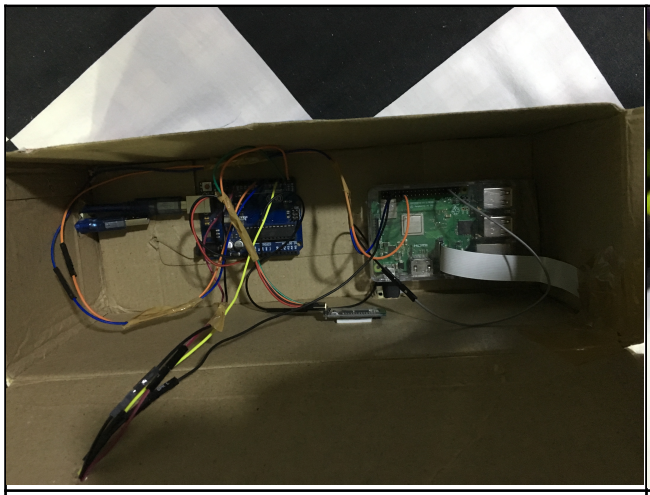

Figure B1. Main hardware

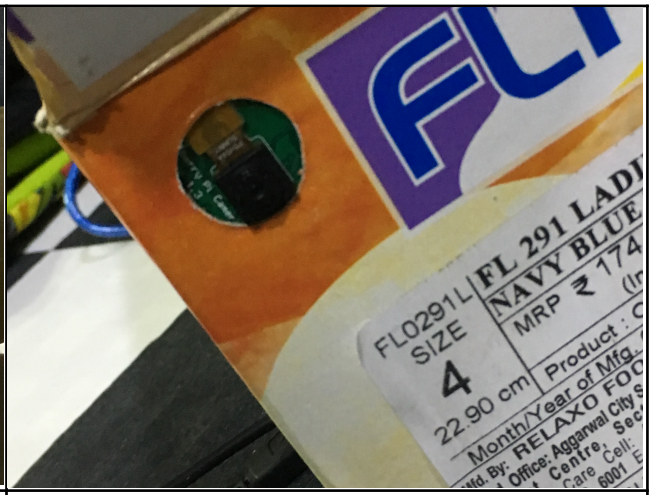

Figure B2. Raspberry Pi camera

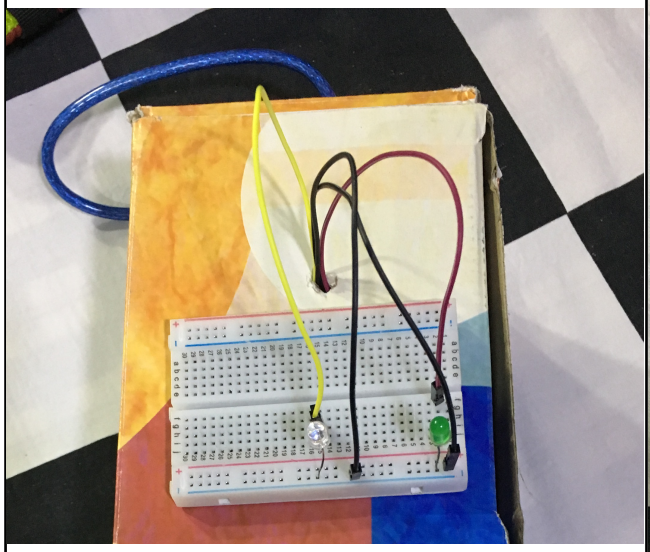

Figure B3. Infrared and EEG connection signal LED

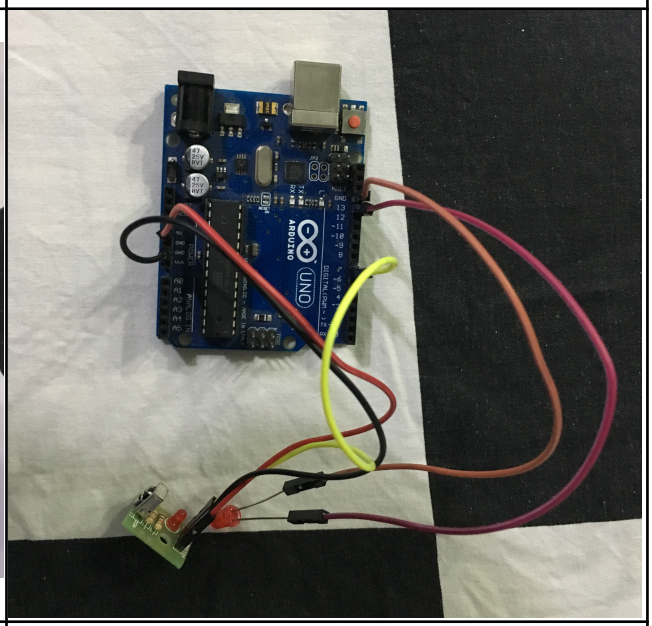

Figure B4. Remote IR reciever with LED