Journal of Engineering Technology and Applied Physics

Voice Control Smart Home Electrical Appliances for Visually Impaired Person

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https://doi.org/10.33093/jetap.2022.4.2.3
Manuscript Received: 1 June 2022, Accepted: 20 June 2022, Published: 15 September 2022

***Abstract* — This paper proposed a voice control based smart home electrical appliances for visually impaired person. This voice control smart home system decreases the time taken for visually impaired person to control their home electrical appliances by giving specific voice command compared to traditional switch or remote control. Besides, the voice control smart home system also contained a mini speaker to provide a feedback audio and ensure the correct electrical appliances were controlled. The implementation of this voice control smart home system provides a more convenient and efficient way for visually impaired person to control their electrical appliances. An experiment was conducted by 50 participants to collect the data of the accuracy of the developed system with testing 100 times voice commands for each participants. The participants achieved 96.74 times correctly on average, with the accuracy 96.74% on this system. 79.33% of the participants agree or strongly agree that would use this system in the future for controlling their home electrical appliances.**

***Keywords*—Voice recognition, Visually impaired person, Smart home, Electrical appliances, Control system**

I. INTRODUCTION

Nowadays, short-sightedness, farsightedness, and astigmatism are common vision issues that many people faced but most of these issues can be solved by pairing an eyeglasses or having eye surgery. However, there are some people are not able to recover back to normal vision, called visually impaired person. Visually impaired person are not only the blindness people but also the people who having limited view and blurry vision that unable to treat. World Health Organization (WHO) show that at least 2.2 billion people have this vision impaired issues around the world [1] and most common causes of vision impairment are diseases such as cataracts, glaucoma, uncorrected refractive errors and etc.

Visually impaired person faced many problem in their daily life including hard to identify external information, societal stigma, manage their home electrical appliances and etc. Visually impairment person hard to trigger their home electrical appliances due to they need to identify the switcher with braille text and accident might happen if there are any obstacles block their path. Therefore, smart home control system should be implemented to replace the conventional switcher control and help visually impairment person manage their home electrical appliances easily.

Smart home system based on Android application was proposed to allow user control their home electrical appliances wirelessly through Bluetooth communication [2]. There are three types of control ways including modified low voltage activating switch, window GUI, and Android GUI. This system able to control the home electrical appliances portably but visually impairment person is not able to watch the smartphone or computer screen clearly. Besides, Bluetooth technology has limited coverage and the computer also need to be power on all the time to control the home electrical appliances. IOT based automation system for smart home was introduced for monitoring the home status and controlling the electrical appliances through smartphone control with Wi-Fi communication [3]. There are several electronics components including temperature sensor, PIR motion sensor, humidity sensor, and buzzer are used for security purposes and allow user to check the home status all the time. However, the disadvantages of this system are not able to add more sensor or devices due to the limited number of pins on the microcontroller. This system also not suitable for

visually impairment person because they not able to watch the screen clearly and control it well. Besides this, S. Zhihua published the design of Zigbee-based smart home system for user to control their home electrical appliances through Zigbee and Wi-Fi wireless communication [4]. This system consumes less energy, controls multiple devices, reduces assumptions, and can even control the devices through the internet. However, this system has slow data transfer rate and a variety of Zigbee device versions, making it extremely costly and unreliable. A comparison of wireless technology was published with comparing RF, Bluetooth, Zigbee, and Wi-Fi wireless communication technique [5, 6]. Since Wi-Fi wireless technology has wider coverage range, strong security, universality, low cost and more reliable than others wireless technologies. Thus, Wi-Fi wireless technology can provide wider range of coverage and more secure than others for controlling the home electrical appliances.

Due to the visually impairment person are not able to watch the smartphone or screen clearly, there are several paper have been published for visually impairment person to control their home electrical appliances without using smartphone. Bluetooth network-based remote controlled home automation system [7] was developed to help visually impairment person manage their home electrical appliances with a portable control panel. This system divided into two section: remote control and controlled system. The remote control was designed with several push button as a keypad to trigger their home appliances through Bluetooth module. The controlled system will control the desired home electrical appliances when receive the specific signal from control panel. This system are portable where make visually impairment person more convenience to manage their home electrical appliances and this system also can control more devices by adding the push button on the control panel. However, the control panel does not have label braille text for visually impairment person to recognize the button and it might cause failure to control the desired home electrical appliances.

Wi-Fi based smart home electrical appliances remote for visually impaired person [8] was developed which more advantages than previous paper. This system using Wi-Fi communication technology to control the home electrical appliances which having wider range of coverage compare with Bluetooth technology. The control panel also has label with braille text for visually impaired person to recognize the button and also a speaker to feedback the selected button. This system able to add more devices since it uses frequency synthesizes controller but the control panel will build larger if add more push button on the control panel. Since the portable devices can make visually impaired person to control their home electrical appliances easily compare to the walking through to the swither. Hence, a portable device will be design with easy for visually impaired person to use instead of using smartphone control or traditional switch.

Based on the research paper [9, 10], voice recognition has more powerful and suitable for visually impaired person to control household appliances among the technologies of mechanical remote control or smartphone control. The current market prioritises voice recognition module because of its excellent accuracy, performance and stability compare with the traditional switcher control. Besides that, voice recognition technique is quite commonly used in our daily life such as translator, smartphone assistants, vehicle management, and household appliances control. In addition, the paper [11, 12] built a voice control system using voice recognition module which make it more reliable to use in controlling the electrical appliances. Last but not least, the researcher paper [13, 14] proposed the design of deep learning algorithms for IOT application and it has strong computation algorithms and high accuracy to perform the recognition technique. Thus, voice recognition is commonly accepted and preferred compare to the traditional switcher or button remote control.

In this paper, a voice recognition system will be proposed for replacing the mechanical switch button. This voice recognition technique provides more convenience and high efficiency for visually impairment person, since they are not require to identify the remote control button, walk through to the switch that mounded on the wall, and also control using smartphone. Voice control panel in hardware and voice recognition algorithm in software will be developed to identify the visually impairment person's voice command to control their desired household appliances. This will enable the visually impairment person control household appliances by giving voice command and does not need to go through to the switch that mounded on the wall or recognize the button of the remote control.

The paper is organized in the following way: Section II will be briefly comments on the voice control smart home electrical appliances module. Section III presents the recommended voice commands detection and its algorithms and section IV reports some experimental data and results. Lastly, in section V, conclusion and some envision future developments is drawn. You are strongly encouraged to directly transfer your article into this document to ensure total compliance to the format. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-levelled equations, graphics, and tables are not prescribed, although the various table text styles are provided.

II. VOICE CONTROL SMART HOME ELECTRICAL APPLIANCES SYSTEM DESIGN

This section discusses the system design for the voice control smart home electrical appliances system. It consists of hardware architecture and software modules of the system as described in section A and section B below.

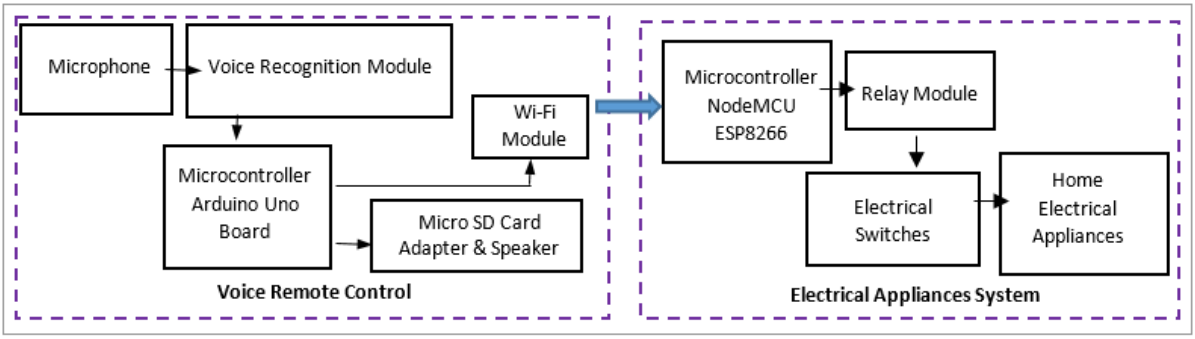

Fig. 1. Voice control smart home electrical appliances system.

A. Hardware Architecture

Figure 1 shows the hardware architecture for the proposed voice control smart home electrical appliances system. The overall system consists of 2 parts: voice remote control and electrical appliances system.

The voice remote control consists microphone, voice recognition module, microcontroller Arduino Uno board, speaker, and Wi-Fi module. Besides, electrical appliances system consists of microcontroller NodeMCU ESP8266, relay module and electrical switches. Microphone is used to receive the voice signal given by the user and transmit the signal to voice recognition module.

Voice recognition module is responsible to recognize the user's commands and pass the correct signal to the microcontroller to perform desired output. Microcontroller send the signal to the electrical appliances system through the Wi-Fi module. At the same time, microcontroller control a mini speaker to give a feedback sound to ensure the correct given command from user.

The feedback sound will be read from the Micro SD card adapter (recorded feedback sound inside micro SD card adapter) and provides the feedback sound to the user through speaker. Electrical switches connected to the relay module and controlled by the microcontroller NodeMCU ESP8266 while receive the signal from the control panel. Thus, the household electrical appliances are able to control wirelessly by giving the voice commands using the voice remote control.

(i) Voice Recognition Module V3

Voice Recognition Module V3 was selected to control the household electrical appliances due to its high accuracy, large memory storage, effectively and portability compare to other modules shown in Fig. 2. It is a speaker-dependent voice recognition module and it need to be train for recognizing the voice commands before using. It can store up to 80 voice commands and it only can work 7 voice commands at the same time, with each voice commands 1500ms. It also has two controlling ways: serial port interface and general purpose input/output (GPIO).

Fig. 2. Voice Recognition Module V3.

(ii) Arduino UNO

The voice recognition module V3 is interfacing by Arduino UNO board. Arduino Uno microcontroller was selected due to it is open sources, inexpensive cost, great architecture, simple programming environment, and simple hardware and software structure.

The proposed Arduino UNO board is manipulating the speaker feedback commands, receive the signal from voice recognition module and transmit signal to the Wi-Fi module to communicate with the electrical appliances system. The operating voltage of the Arduino Uno will be 5V by connecting to the 5V battery power sources. 5V pin of Arduino UNO board provides constant 5V supply to voice recognition module, micro SD card adapter, speaker and Wi-Fi module and all the ground (GND) pin of all the electronics components are connected to pin GND of Arduino UNO board for grounded as shown in Fig. 3.

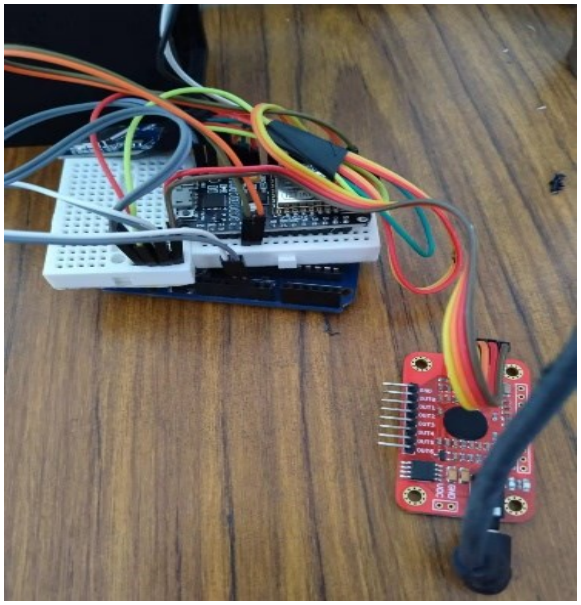

Fig. 3. Voice recognition module connect to Arduino UNO.

(iii) Micro SD Card Adapter & Speaker

The 6 digital pins of micro SD card adapter (CS, MOSI, MISO, SCK, VIN and GND) are connected to the microcontroller for reading the feedback sound's file to provide feedback sound to the user through speaker shown in **Error! Reference source not found.**. There are 2 pins (VIN, GND) of speaker connect to the microcontroller to provide the feedback sound. When the microcontroller receives the signal from voice recognition module, it will read the desired feedback audio file from the micro SD card adapter and provides desired output audio feedback through the speaker.

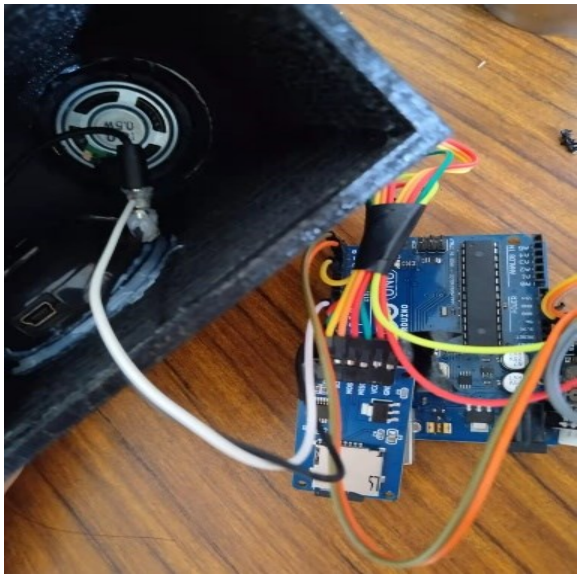

Fig. 4. Micro SD card adapter and speaker connect to Arduino UNO.

(iv) NodeMCU ESP8266

Wi-Fi communication technique was chosen due to it has wider coverage of wireless range, universe and cheap compare to other technique. In voice remote control, NodeMCU ESP8266 is responsible as a Wi-Fi module to transmit the signal from the Arduino UNO microcontroller to another microcontroller at electrical appliances system side. Arduino UNO microcontroller (TX, RX pins) is connected with Node MCU ESP8266 by using serial communication technique so that they can communicate with each other shown in Fig. 3.

In electrical appliances system side, NodeMCU ESP8266 responsible as a microcontroller and Wi-Fi module since it can control the relay module. It uses to control the desired electrical switches when receive the signal from the voice remote control through the Wi-Fi communication technique shown in Fig. 5.

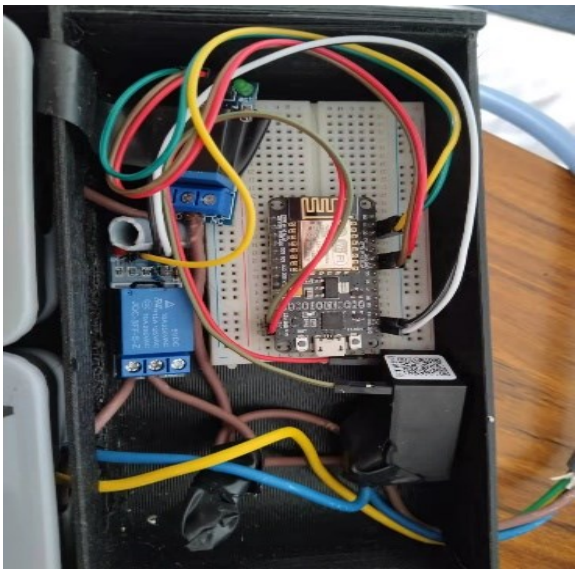

Fig. 5. Node MCU ESP8266 in electrical appliances system side.

(v) Relay Module

The SPDT relay was implemented to control the electrical switches when receive the signal from the NodeMCU ESP8266. The relay module connected to one of the electrical switch wirings shown in Fig. 5. It is responsible to open or short the circuit to control the current flow through the appliances switches or open the circuit loop. The extension socket is chosen as electrical switches to connect the household electrical appliances so that it is not limited to control specific electrical appliances but the electrical appliances with 3 pin plug as shown in Fig. 6.

Fig. 6. 3 pin plug.

B. Software Implementation

The software implementation for the Voice Control Smart Home Electrical Appliances system consists of three portions: (1) Voice Recognition Module Controlling, (2) WiFi Communication and (3) Voice Control Smart Home Electrical Appliances Algorithms. Voice Recognition Module Controlling and WiFi Communication will be discussed below, whereby Voice Control Smart Home Electrical Appliances Algorithms will be focally discussed in Section III.

(i) Voice Recognition Module

The voice recognition module V3 can store up to 80 voice commands but only can work 7 commands at the same time. In order to control the switches in a faster way, user can give the command directly to trigger the switches. For examples, the user can give the command (1st ON / 2nd ON) to trigger the first and second switches within 1.5 seconds.

Besides, it might not be having enough voice commands to store in group 1 if need to increases the number of electrical appliances. Therefore, the system need to switch from group 1 to group 2 for controlling more electrical appliances. For example, the user gives a voice command (Port) to the system, the system will switch to the group 2 automatically and waiting the user to give the second commands (1 to 7) to select the desired switches. After selected the desired switches, the system will automatic switch to group 3 for turning on or off the desired switches. Hence, this system able to control 2 switches within 1.5 seconds or control other 5 switches by switching the group. The overall software architecture for voice recognition control system shown in Fig. 7.

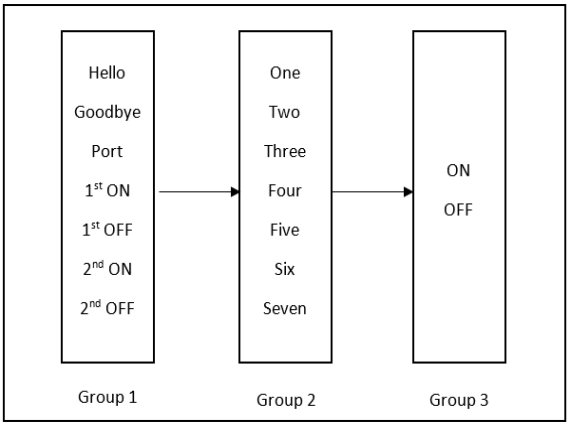

Fig. 7. Software architecture for voice recognition control system.

(ii) Wi-Fi Communication

The software implementation for communicate between both ESP 8266 Wi-Fi module was discussed in this section. ESP 8266 Wi-Fi module was used to transmit and receive data wirelessly between the voice remote control and electrical appliances system. In this project, server client was created using HTTP (special protocol) to allow both ESP 8266 to communicate each other, as illustrated in Fig. 8. ESP 8266 in voice remote control side act as a client while another ESP 8266 in electrical appliances system side act as a server. Station mode, soft access point mode, and a combination of the two modes are available on ESP 8266. For station mode, ESP 8266 connect to the router by obtaining the router's IP address in order to configure the web server and access to the devices within the existing network. The router assign ESP 8266 a local IP address by specifying router's SSID and password to log in to the network. For the soft access point (AP) mode, ESP 8266 develops its own network with a maximum of 5 stations that can connect to it.

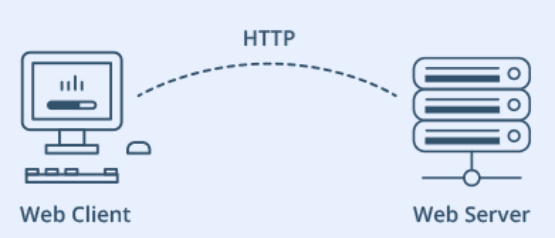

Fig. 8. Server client HTTP technique.

This project used station mode (STA), which allows ESP 8266 to communicate with each other over an existing network. The first step in setting up the ESP 8266 Web server is create an HTTP server. Besides, the web server was configured with default port (port number 80). The web server communicates with the client using the IP address of the ESP 8266 as the URL.

After initialising the web server, it will continue to listen for the HTTP requests from the client and manage the desired electrical appliances once the request command is received. The client's HTTP request was received using the HTTP GET technique. The client will connect to the server using the ESP 8266 web server's IP address and send a specific request using the URL format:

GET Light1_ON HTTP/1.1

GET Light1_OFF HTTP/1.1

GET Light2_ON HTTP/1.1

GET Light2_OFF HTTP/1.1

The server will receive the client's URL and encode it to match the URL that the server has established. The server will operate the desired electrical appliances and also reply to the client displayed in Fig. 9 after the URLs are matched.

```
Server------------------------------
New client
From client = GET Light1_On HTTP/1.1
Server send = LED Status : On
Client disonnected
------------------------------------

Server------------------------------
New client
From client = GET Light1_Off HTTP/1.1
Server send = LED Status : Off
Client disonnected
------------------------------------

Server------------------------------
New client
From client = GET Light2_On HTTP/1.1
Server send = LED Status : On
Client disonnected
------------------------------------
```

Fig. 9. URL with HTTP GET method (Server).

III. VOICE CONTROL SMART HOME ELECTRICAL APPLIANCES ALGORITHMS

The template matching technique is proposed to the develop voice control based smart home system, and there are two modes in this voice recognition module: train mode and matching mode. The overall flowchart for the Voice recognition process is shown in Fig. 10. Before using this system, the voice recognition module need to be train the voice commands and store the signal into the references speech storage. After finishing the train mode, the voice recognition module will switch to matching mode which is to match the new capturing input voice and the stored references speech pattern by using template matching technique. For the train mode, step 1 until step 4 will be run to training and store the trained input speech. For the matching mode, step 4 will be skip and proceed to step 5 for apply matching speech pattern.

Step 1: **Voice Commands Capturing:** Capturing the voice commands given by the user by using the microphone. Microphone convert the acoustics signal into voltage for voice recognition module able to read the signal.

Step 2: **Sampling Voice Signal:** An analogue signal captured from the microphone since all the sound signal are perform a continuous

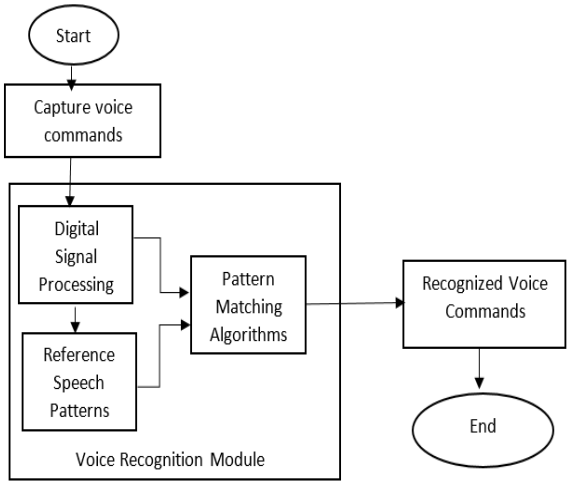

Fig. 10. Voice recognition process flowchart.

waveform in the interval of time. However, the computer only can read the digital signal so the analogue to digital conversion was introduced. There are two process to convert the analogue signal to digital signal: sampling and quantize. Sampling process will convert the analogue signal to discrete signal by taking samples (audio data) from the analogue signal. The sampling rate is the number of samples in one second with the formula:

$$Sampling\ Rate = \frac{1}{Sampling\ Interval}$$

There are several examples with 2 kHz sine wave signal and different sampling rate 30 kHz, 3 kHz, and 4 kHz to test the accuracy. Figure 11 shows the 30 kHz sampling rate able to capture more accurate results of the original signal when perform the sampling process.

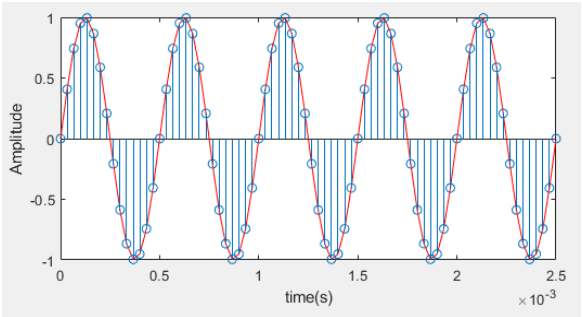

Fig. 11. 30 kHz sampling rate.

Another example illustrates 2 kHz sine wave signal with 3 kHz sampling rate shown in Fig. 12. In Fig. 12, the discrete signal might loss some important information from the original signal due to the lower sampling rate that result larger sampling interval in a signal.

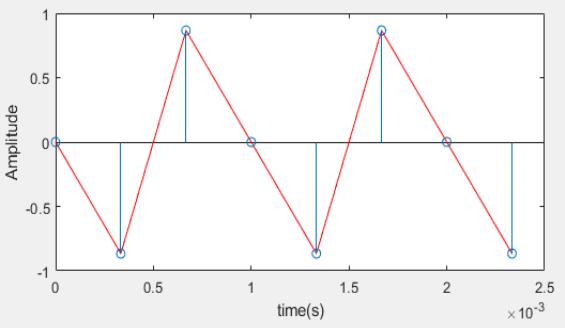

Fig. 12. 3 kHz sampling rate.

Figure 13 shows the 2 kHz sine wave signal with 4 kHz sampling rate. The discrete signal results a horizontal line where all the samples pointing at 0 amplitude, and this problem called aliasing. Nyquist Theorem was introduced where the sampling frequency larger than double of the maximum frequency ($F > 2F_{max}$). In Nyquist Theorem, the higher the sampling rate will produce more accurate results when sampling a signal. If the sampling frequency equal or lesser than double of the original signal, it might cause aliasing problem and loss some important information during the sampling process.

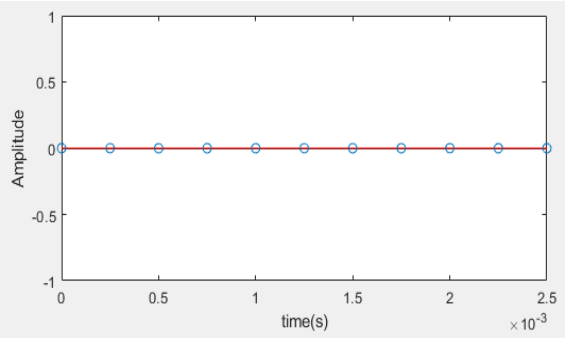

Fig. 13. 4 kHz sampling rate.

Step 3: **Digitize the Voice Signal (Quantization):** The next process of digitizing the signal called quantization. Quantization process is used to convert the discrete signal to digital signal by rounded the amplitude of the discrete signal to the nearest quantization level. Figure 14 shows the amplitude of the discrete signal has (–4V, 4V) quantization levels and 4 bits quantization bit. To transform the samples to the nearest quantization level, the separation between two levels known as step size to quantize the samples to digital form. The number of quantization bits influences the step size with the formula:

$$\Delta = \frac{2m_{\max}}{L} = \frac{m_{\max x} - (-m_{\max})}{L}, L = 2^R$$

Symbol Δ is the step size where equivalent to the summation of the range of amplitude ($-m_{max}$, m_{max}) divided by the number of quantization levels ($L = 2^R$). R is the number of quantization bit. The higher the quantization bit, the more the number of the step size that results more smoothly digital waveform without losing important information.

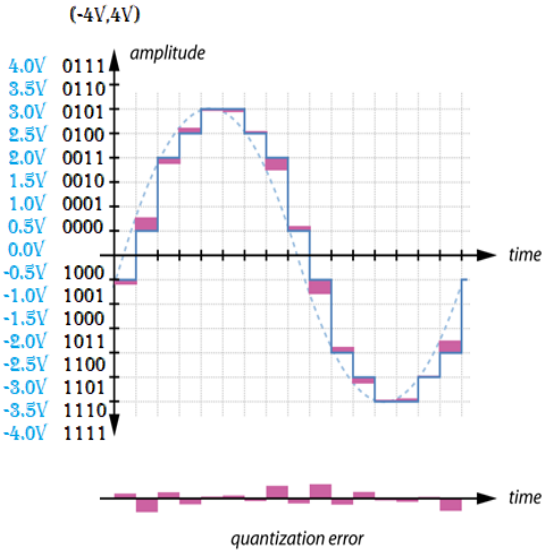

Fig. 14. Quantization process.

Step 4: **Storing References Speech Pattern:** In train mode, the input voice signal will be converted from analogue to digital signal through step 2 and 3. After the input voice signal was applied the signal processing, the input voice signal will be store into the voice recognition module as a reference speech.

Step 5: **Template Matching Algorithms:** Template matching algorithms was used in this system where compare the unknown input speech with the stored speech to do the recognition by calculating the shortest distance of the vector sets. Template matching is a simple computing algorithms and also having high accuracy to do the recognition. In order to match the speech, Euclidean distance was used to calculate the vector sets of the unknown input speech with all the stored speech ($P = (p_1, p_2, p_n)$), $Q = (q_1, q_2, q_n)$ and the shortest distance of the vector set will be considered as the recognized speech.

IV. EXPERIMENTAL RESULTS

In this section, the application of the proposed voice control based smart home system will be illustrated. It will cover the product overview, results and discussion of the survey data collection, accuracy system testing, and time taken by the voice control system. The voice control based smart home system was tested with visually impaired person within Malacca Malaysia.

A. Product Overview

The final prototype of the voice control based smart home system is shown in Fig. 15. The voice recognition module, Arduino UNO, Wi-Fi module, speaker is stored inside the voice remote control shown in left hand side of Fig. 15. Besides, Node MCU ESP 8266, relay module, switches are stored inside the electrical appliances system shown in right hand side of Fig. 15. The microphone is used to give the specific voice commands to control the switches. When the voice recognition module recognizes the voice command successfully, the speaker will give a feedback sound to ensure the given voice commands is correct. At the same time, the signal will transmit from voice remote control to electrical appliances through Wi-Fi module. The electrical appliances will be control by following the received instruction from the voice remote control.

Fig. 15. Final prototype of voice remote control based smart home system.

B. Test Run Results

The performance of the voice control based smart home system was test run in the blindness centre in Malacca Malaysia. The experiment tested between 50 visually impairment persons in range of age from 18 to 80 years old. Each person must contribute 100 times to test this system with any voice commands during the experiment. 50 times to test the quick commands (give group 1 commands only) such as 1st ON, 1st OFF, 2nd ON, and 2nd OFF. Another 50 times to test the long commands by switching the group from 1 to 3 (Port…one…ON, Port…two…ON, Port…one…OFF, Port…two…OFF) shown in Fig. 16. Before using this system, they were instructed to train the voice recognition module and each records limited in 1500 milliseconds. There will be a total of 5000 times to test the voice control smart home system in this experiment (50 participants with 100 times test for each participants). This experiment objective is to determine the reliability, usability and accessibility of this voice control smart home system by calculating the successful rate between 5000 times of the voice commands. The rate of accuracy will be calculated by applying the formula:

$$Rate\ of\ Accuracy = \left(\frac{Successful\ Attempt}{Total\ Attempt}\right) \times 100\%$$

The total number of successful attempts in this experiment is 4837. Hence, the rate of accuracy of this system is 96.74% by applying the equation above. Figure 17 shows a pie chart with the percentage of the accuracy of the whole system has 96.74% successful trigger the correct electrical appliances and 3.26% of failure.

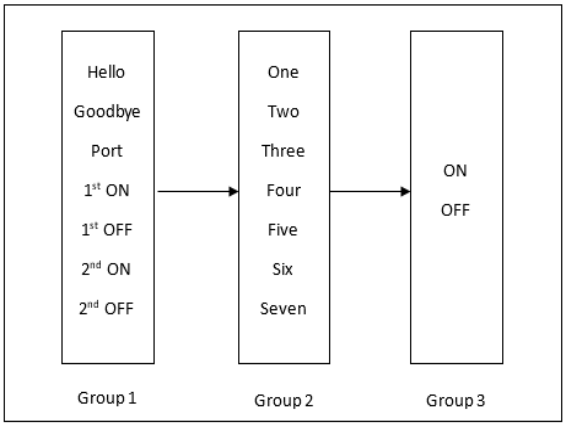

Fig. 16. Instruction of running the experiments.

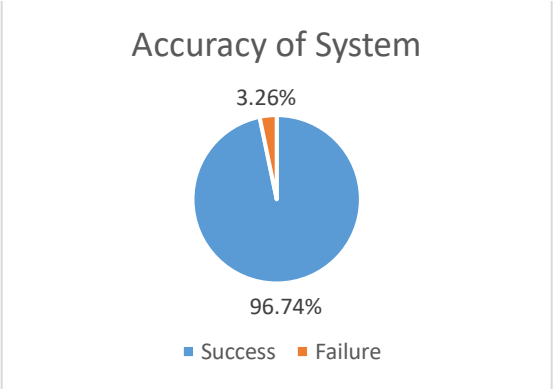

Fig. 17. Pie chart with percentage of accuracy.

Besides this, the time taken during this experiment also recorded by all the visually impaired participant with 100 times turn on/off the electrical appliances. The average time taken during this experiment are 11.215 minutes to complete the task. Other than that, 50 good visually person also invited to complete this experiment in Fig. 18. The average time taken for good visually participants are 9.625 minutes to complete the task. As the results, the time taken between the good visually person and visually impaired person only have slightly different time taken during manage the electrical appliances.

Fig. 18. Conducted experiments on site.

C. *Product Survey Analysis*

A survey was conducted onto visually impairment person to determine the usability of the voice control smart home system. There are three questions about the usability of the system using Likert scale shown in Table I. Generally, majority of the visually impaired person agreed/ strongly agreed that this system is ease of use due to control their home electrical appliances without moving to the switches that mounded on the wall. The results are shown in Fig. 19. Besides this, 80% of them agreed that this voice control based smart home system can help them to control their home appliances well. Most of them are willing to replace the remote control or switches that mounded on the wall with this voice control based smart home system. As the result, 79.33% of the respondents believe that this voice control based smart home system is useful for them to activate/deactivate their home electrical appliances and give positive feedback shown in the Likert scale. There are 6 persons disagree this system assist them to control their home electrical appliances due to hard to access a new technology and might disturb others at night when using this system.

Table I: Likert scale of the usability survey data for the system.

	Number of Persons				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Q1 The Voice control based smart home system was easy to use	0	3	5	27	15
Q2 The Voice control based smart home system assisted me manage the electrical apppliances well	0	4	5	26	15
Q3 This voice control based smart home system would be used in the furtue for controlling my home electrical appliances	0	6	8	27	9

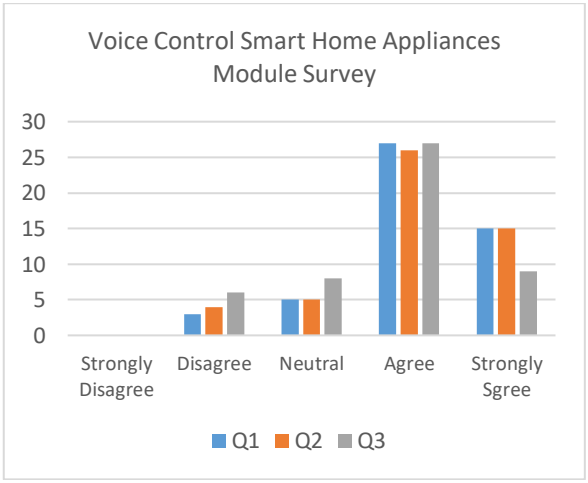

Fig. 19. Bar chart surveying.

V. CONCLUSION

A voice remote control based smart home system is developed to assist visually impaired person to manage their home electrical appliances by giving specific commands. In this case, it improves the quality life of visually impaired person to become more convenient and efficient. Furthermore, the implementation of voice control smart home system can totally recognize the user's commands and able to control their desired electrical appliances by giving the commands without moving to the switches. There is a mini speaker installed in the voice remote control to give a feedback commands. Therefore, the visually impaired person can ensure that the desired electrical appliances are controlled correctly. Moreover, the voice remote control was developed with Wi-Fi

technology and having independent power supply. Thus, visually impairment person can control their home electrical appliances anywhere by taking the voice remote control. In addition, an experiment was conducted with 50 visually impairment person in Malacca Malaysia by testing 100 times for each persons with any voice controlled alternatives, and 96.74% of accuracy to use this proposed system. The average time taken to test this system is around 10.875 minutes to complete the task. A survey also was conducted by questioning them the usability of the voice control based smart home system. Majority of them strongly agreed/agreed that can assists them to control their home electrical appliances and willing to implement this voice control based smart home system.

However, the proposed voice control based smart home system does have some limitation. The reasons that cause failure to control the desired home electrical appliances are similar /wrong pronunciation and also give the commands too quickly/slowly. Some of the visually impaired persons are not fluent in speaking English, and might causes failure or control wrong home electrical appliances. Besides, the voice recognition module are not able to detect the commands if the user give the commands too slowly due to the limited time (1500 milliseconds per commands). Therefore, 6 survey respondents disagreed to use this system due to the limitation of this system and also they worry to disturb others at night when using this system.

The recommendation has been recorded from the visually impairment persons for the future improvement of this system. Due to the voice recognition module V3 has limited time to record a voice commands, the system will focus on the more advantages and powerful voice recognition module to control their home electrical appliances for the future enhancement. Besides, the current version of the system does not have a battery reminder for visually impairment to recharge the battery. They suggested to add the battery reminder feature through the speaker otherwise they might not to use this system in low battery level. In addition, most of the visually impaired persons are familiar in Malay languages rather than English. They suggested to add more languages available to control the home electrical appliances instead of limited in one language. Lastly, the current version of the system only can work within the same router due to the use of HTTP technique. In the future, the system might add its own telco package so that they can control their home electrical appliances anywhere.

ACKNOWLEDGEMENT

The supporter of this research is the IR FUND under Multimedia University of Malaysia. (Grant No. MMUI/220018).

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