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Proof of Concept for Automated Electrical Appliances Operation Via Android Voice-Controlled

'Arifahtun Najwa Mohd Rafi[1], Siti Marwangi Mohamad Maharum[2]
[1]Section of Electrical Technology
[2]Section of Electronics Technology
Universiti Kuala Lumpur British Malaysian Institute

Corresponding email: sitimarwangi@unikl.edu.my

Abstract: Internet of Things (IoT) is a concept developed to enable remote accessibility via Internet to control and monitor devices that are connected to it. Switches that are used to control the on-and-off operation of household appliances, may cause electrocution if they are touched with wet hands and sometimes, the elderly or disabled person's hands could not reach the switches due to their installation location that are usually mounted at certain heights on the walls. The goal of this project is to execute a proof of concept (PoC) development that will demonstrate the feasibility of automatic electrical appliances operation via verbal instructions. In this PoC development, a programmed NodeMCU ESP8266 microcontroller is integrated with a Google Assistant platform and If This, Then That (IFTTT) application to receive verbal commands to turn on and off light-emitting diodes (LEDs) automatically. Through a pilot test on the integration of hardware and software development, this project has successfully enabled turning on and off lights by using voice instructions in less than 4 seconds in quiet surroundings. Meanwhile, less than 7 seconds were required to automate the operation of the lights in noisy surroundings. With the success of functionality proof, it is anticipated that this PoC could be realized in terms of prototype development on real electrical loads such as ceiling lights, bulbs and wall fans and would certainly benefit society with the affordable deployment of home automation.

Keywords: Voice-controlled home automation, IoT, Google Assistant application

1.0 INTRODUCTION

The IoT is a network of physical objects or things equipped with sensors, software, and other technologies to connect to other devices and systems and exchange data over the Internet. Through IoT platforms, it is possible to identify which data is useful and which can be discarded in order to recognize patterns, provide recommendations, and locate problems, often before they actually occur [1].

Other than that, IoT is a concept of interconnected computer networks that enables the transmission of data without the need for human-computer interaction. In addition, the IoT deployment could create a low-cost home automation system that allows users to remotely control their many devices using voice recognition technology simply by using their smartphones.

Household electrical appliances usually use a manual switch to turn an electrical appliance on and off. This can cause some people to get electrocuted if they touch the switch with wet hands without drying it first. This is very dangerous, especially for housewives and elderly people who may sometimes forget to wipe their hands after washing their hands and directly touch the broken case of the switch with wet hands.

It also causes inconvenience for users who are elderly and do not have the strength to walk to the place where the switch is located. It is also difficult for disabled users, especially blind people to find a switch to turn household appliances on and off. This can endanger their life, as it increases the likelihood that they will trip or bump into something on their way to the switch.

Based on the above-mentioned problems, there is a need to automatically turn on and off the household appliance using only voice instruction. Several methods for voice-controlled home automation have been proposed in previous works [3] and [4]. For instance, researchers in [3] proposed a design and implementation of a home automation system using a Raspberry Pi microcontroller. The project uses a device equipped with three methods of communication with various home appliances. It provides a low-cost and versatile solution for home control and monitoring by using a Raspberry Pi with IP connectivity to access and operate appliances and devices using an Apple Home and smartphone applications that are based on Android.

On the other hand, researchers in [4] have shown how Global System for Mobile Communication (GSM) technology can be used to control home appliances as part of a smart home system. The GSM module is used to receive a short message service (SMS) from the user's cell phone that instructs the controller to turn on and off the household appliances such as lights, air conditioners, etc. When the microcontroller receives the SMS command, it automatically controls the operation of the electrical appliance by setting them according to the user's preference ON or OFF. It simply reads the messages from the cell phone and controls the electrical appliances based on the messages received.

Conversely, this project is aimed at developing a PoC that would prove the feasibility of automating the operation of the electrical appliance through voice instruction. To achieve this feasibility evaluation, an affordable NodeMCU microcontroller called ESP8266 is chosen to process the voice instructions received by the Google Assistant on an Android smartphone.

The paper is arranged as follows. Section 2 is devoted to the description of the project methodology and the results obtained from this PoC development are presented in Section 3. Finally, Section 4 summarizes this paper.

2.0 PROJECT METHODOLOGY

Figure 1 shows the block diagram of the proposed automated electrical appliances operation via Android smartphone. Inputs are made automatically by using Google Assistant with voice-only instructions. The Google Assistant allows users to command the predefined voice instructions after the users simply say "OK Google" or "Hey Google". Google Assistant controls the connected devices and after it receives instructions from the application called If This Then That (IFTTT). IFTTT is a software platform that connects various third-party applications, tools and services to launch various automated systems.
In this paper, ESP8266 is selected for PoC development because it is a low-cost with built-in WiFi microchip with a full Transmission Control Protocol/Internet Protocol (TCP/IP) stack and other microcontroller capabilities. ESP8266 receives the signal from the IFTTT server, which acts as a broker and enables data transmission over Wi-Fi. The Arduino IDE software is used to connect an ESP8266 microcontroller to a registered Wi-Fi hotspot. This microcontroller provides hardware integration with the targeted appliances. In this PoC development, LEDs are used to represent the electrical appliances and their operation will be automated without the need to be

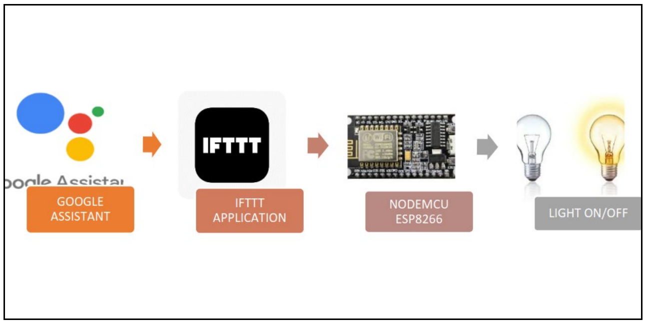


Figure 1: Block diagram of the proposed automated electrical appliances operation via Android smartphone

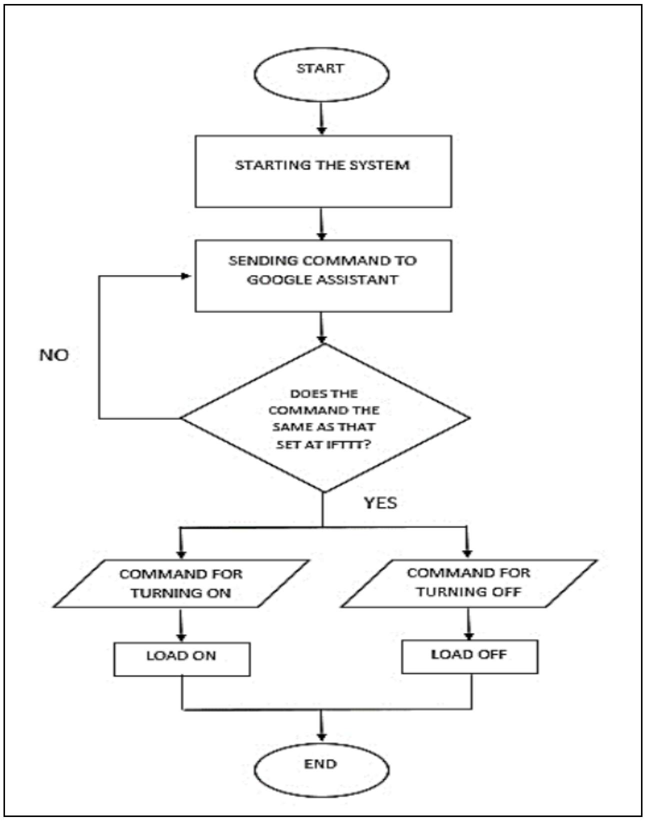


Figure 2: System operational flowchart of the proposed automated electrical appliances operation via Android smartphone

manually controlled using switches.

As shown in Fig. 2, the system begins operating immediately when it is connected to a 5V power supply and the ESP8266 microcontroller is connected to a registered WiFi. Without a WiFi connection, the proposed voice-controlled could not be realized. After connecting to the Internet, Android smartphone users can just issue a command by saying "Hey Google" or "OK Google" to launch the Google Assistant application from their Android smartphones.

Other than that, Google Assistant can also be activated manually by turning on the application. Once the Google Assistant is launched, the users can just provide verbal instructions to turn on or off the dedicated LEDs at the output part. For instance, the user will need to mention "Turn on Light 1" to turn on the LED 1 operation. Other than that, to turn off LED 2 operation; the user can use the "Turn off Light 2" command.

The process goes to the IFTTT application to determine whether or not the instructions given match those given in the application. If the given instructions are not the same, Google Assistant cannot respond and the process is repeated with the same instructions. This also happens when Google Assistant is unable to recognize the voice in a very noisy environment. If Google Assistant is able to recognize the given commands, the lights will be turned on or off according to the given instructions. Then the process of operating this PoC ends.

Figure 3 shows the circuit connection of the proposed PoC development. The NodeMCU ESP8266 has a maximum clock speed of 160MHz, 128KB Random Access Memory (RAM), and 4MB of flash memory. The operating current is 80mA in average. The first LED is connected to NodeMCU ESP8266 through pin D1 or known as GPIO5, and the second LED is connected to D2 (i.e., GPIO4). The GPIO pin numbers on the ESP8266 match one-to-one with the corresponding pin numbers in the Arduino IDE. The power supply is connected to NodeMCU on the Vin and Gnd pins to convert the electricity coming from the source so that it has the correct format and voltage.

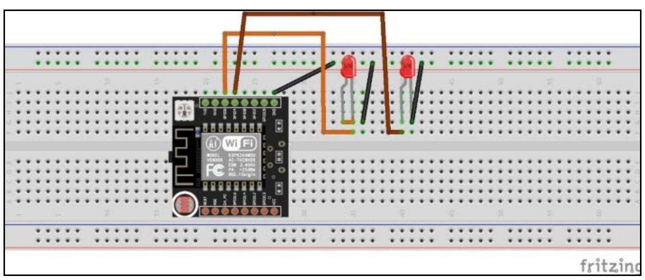


Figure 3: Circuit connection of the proposed PoC development

3.0 RESULTS & DISCUSSION

Table 1 lists the corresponding output of this project when integrated with Google Assistant for voice instruction recognition. When an instruction is inputted to Google Assistant, the output will be produced following the given instructions accordingly. In this PoC development, only two LEDs were tested. Hence, Google Assistant responded by turning on the LED 1 and LED 2 operations when "Turn on Light 1" and "Turn on Light 2" were received respectively. Likewise, the LED 1 and LED 2 operations were turned off when "Turn off Light 1" and "Turn off Light 2" were received respectively by the Google Assistant.

As shown in Fig. 4, the LEDs operation may also be controlled using the dashboard of Adafruit IO website by

Table 1: LED operation based on the received voice commands

	Commands received by Google Assistant and processed by IFTTT		**Output**
LED 1	Turn on Light 1	Turn off Light 1	LED 1 turned on / off
LED 2	Turn on Light 2	Turn off Light 2	LED 2 turned on / off

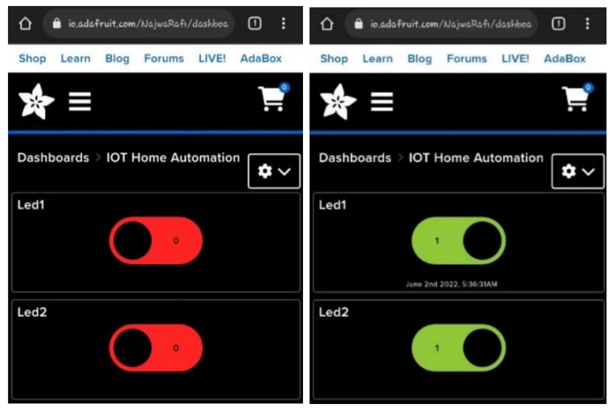


Figure 4: Automation of appliances operation through the dashboard of Adafruit IO website

simply scrolling the operation switch on the dashboard between 0 and 1 to indicate the turn-off and turn-on operation, respectively. This dashboard button control serves as another alternative to remotely control the appliance's operation, which is the LEDs in this PoC development.

Table 2 lists the output (i.e. the LEDs operation) when the LEDs automation operation was controlled via voice commands and switch dashboard settings as shown in Table 1 and Fig. 4. Note that the white LED represents LED 1 while the yellow LED represents LED 2. The output shown in Table 2 proves the feasibility of this PoC development for the proposed home automation.

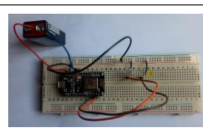
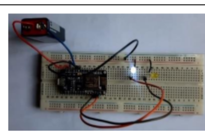
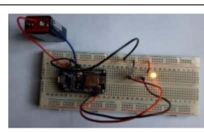
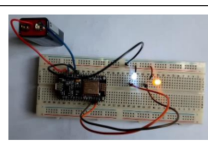
Next, a signal strength test between the transmitter and receiver was performed for this PoC unit. The inSSIDer software was used to generate the graph showing the signal strength at a distance of sixty meters. As can be seen in Fig. 5, this software can be used to determine the strength of the Wi-Fi module which is built-in on the ESP32 microcontroller. Obviously, the generated graph proves that the signal strength decreases as the distance between the transmitter and receiver increases.

The latency between LED 1 and LED 2 is shown in Table 3 and Table 4 for both quiet and noisy environments, respectively. Quiet environment means there is no obvious noise coming from a human or from its surrounding. Meanwhile, the noisy environment includes nearby human conversations, public address (PA) system and other noise sources. Each LED was subjected to two separate tests to determine the latency in processing the received voice command for different background environments. As shown in Table 3, in quiet surroundings; LED 1 took an average of 2.71 seconds and 2.83 seconds to turn on and off when it received verbal instructions of "Turn on Light 1" and "Turn off Light 1", respectively. On the other hand, LED 2 took an average of 3.29 seconds and 2.35 seconds to turn on and off when it received the respective verbal instructions of "Turn on Light 2" and "Turn off Light 2" in quiet surroundings.

Conversely, longer delays were taken by LED 1 and LED 2 to process the voice commands in a noisy environment. As shown in Table 4, LED 1 took an average of 4.06 seconds and 5.27 seconds to turn on and off when it received verbal instructions of "Turn on Light 1" and "Turn off Light 1", respectively. Likewise, LED 2 took an average of 5.24 seconds and 6.00 seconds to turn on and off when it received the respective verbal instructions of "Turn on Light 2" and "Turn off Light 2" in noisy surroundings.

Although there are delays in completing the function of automating the electronic operation, such delays might be considerable for users who are not capable to reach the manual switches at home to turn on and off any electrical appliances. For instance, a disabled person or bedridden patient could still leverage this voice-controlled PoC development to turn on and off any electrical load and appliances remotely in less than 10 seconds.

Table 2: LED operation resulted from the respective voice commands in Table 1

Input from Google Assistant/ Switch button Adafruit IO		**Output light**
ON	**OFF**	
–	White LED Yellow LED	
White LED	Yellow LED	
Yellow LED	White LED	
White LED Yellow LED	–	

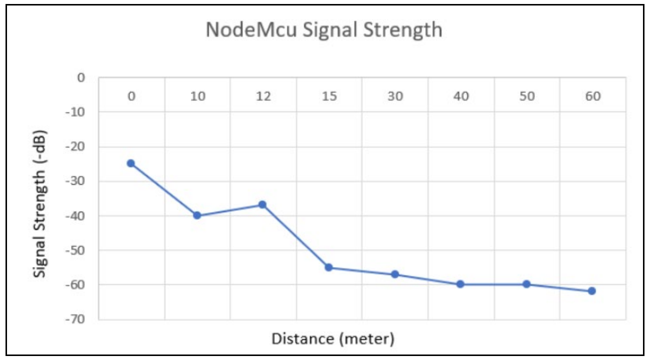


Figure 5: The signal strength test between the transmitter and receiver for PoC development

Table 3: Latency in processing LED 1 and LED 2 operation via voice command instructions in a quiet environment

		LED on delay (second)	LED off delay (second)
LED 1	First reading	3.00s	1.98s
	Second reading	2.42s	3.68s
LED 2	First reading	2.94s	2.35s
	Second reading	3.63s	2.35s

Table 4: Latency in processing LED 1 and LED 2 operation via voice command instructions in a noisy environment

		LED on delay (second)	LED off delay (second)
LED 1	First reading	3.77s	4.56s
	Second reading	4.35s	5.97s
LED 2	First reading	6.16s	5.30s
	Second reading	4.31s	6.69s

4.0 CONCLUSION

From this project, it can be concluded that:

a) a PoC for voice-controlled home appliance has been developed using an Android smartphone device connected to a NodeMCU ESP8266 via WiFi network to turn on and off electrical and electronic operations.

b) The results of the experiments conducted with the two LEDs show the overall PoC operation to remotely control the LEDs operation via verbal instructions which are captured by the Google Assistant application in the smartphone.

c) The results of this experiment also show that a user is able to control a large number of electrical appliances with a single platform in a smartphone at a considerable delay.

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