Design and Implementation of Home Automation Based on Voice Recognition System and IOT using Node MCU

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تصميم وتطبيق منظومة التحكم بأجهزة المنزل بواسطة الأوامر الصوتية وإنترنت الأشياء

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Abstract:

Automation has become a common process at this time, as automation reduces the consumer time to carry out tasks and work to reduce human risks. Given the development of technology, where Android applications are developed periodically to help us in several ways to facilitate life and raise the suffering of the segments of society, we mention from them in our research the elderly and the disabled, as these segments suffer when they alone at home are operating electrical appliances. For the development of sound processing technology by converting it to the texts, this feature was used to control home appliances remotely, as our study combines all these things to provide a home automation system based on an accurate controller and the smartphone is active. Through the Internet, users of this system will be able to control of each device in their homes using voice commands. The Android smartphone, which is almost the choice of everyone these days, is all that the user needs in this project to control of appliances. The practical results show that the user was able to use audio orders effectively using the Android application to play home appliances in actual time.

Keywords: IOT; Node MCU; Home Automation; Voice Commands; Android Application.

الملخص:

أصبحت الأتمتة عملية شائعة في هذا الوقت، حيث تقوم الأتمتة بتقليل الوقت المستهلك لتنفيذ المهام والعمل على تقليل المخاطر البشرية. ونظرا لتطور التقنية، حيث يتم تطوير التطبيقات الأندرويد بشكل دوري لتساعدنا بعدة طرق لتسهيل الحياة ورفع المعاناة عن شرائح المجتمع، نذكر منها في بحثنا هذا كبار السن والمعاقين، حيث تعاني هذه الشرائح عندما تكون لوحدها بالمنزل من تشغيل الأجهزة الكهربائية. ولتطور تكنولوجيا معالجة الأصوات بتحويلها صوتياً إلى نصوص، تم استخدام هذه الخاصية للتحكم بالأجهزة المنزلية عن بعد، حيث تدمج دراستنا كل هذه الأشياء لتقديم نظام أتمتة منزلي قائم على متحكم دقيق والهاتف الذكي يتم تنشيطه صوتيا. من خلال الإنترنت، سيتمكن مستخدمو هذا النظام من التحكم الصوتي في كل جهاز في منازلهم. الهاتف الذكي الذي يعمل بنظام أندرويد، والذي يعد اختيار الجميع تقريبا هذه الأيام، هو كل ما يحتاجه المستخدم للتحكم بالمنظومة. تظهر النتائج العملية أن المستخدم كان قادرا على استخدام الأوامر الصوتية بشكل فعال باستخدام تطبيق أندرويد لتشغيل الأجهزة المنزلية في الوقت الفعلي.

الكلمات المفتاحية: إنترنت الأشياء، المتحكمات الدقيقة، أتمتة المنازل، الأوامر الصوتية، تطبيقات الأندرويد.

Introduction

Due to the fact that wireless technologies play an important part in our daily lives. People can communicate with each other more effectively because of improved communication. Technology makes it simple to communicate with friends and save private information like photos, papers, music, and movies. We connect several devices to the Internet in order to make people's daily lives simpler. The Internet's primary benefit is its ability to establish connections between billions of end devices located all over the world. In order to access and learn about the gadgets we require and we can connect from anywhere. We can save time, energy, and money as this progress is made, the controlling of home appliances via internet network is called as Internet of Things (IOT).

The Internet of things (IoT) easily can be defined as various devices like smart watch, Tablets, Computer, smart light, and CCTV that are connected to the internet. M2M (Machines-to Machines) communication is the previous level of IoT that connect a device to the cloud, managing it and collecting data. With the help of internet very useful and powerful communication links can be created between things and people and between things. The emergence of IoT technology, Home automation topic attract people attention. For helping human being many devices are connected to internet wirelessly. In addition, these devices can remotely control and monitor from any

places to improve the intelligence of home environment. By using IoT technology, we can easily connect with other things to innovate new idea about smart home and can improve the living standard of life [1].

Design homes in the classic way is not the ideal way to help and facilitate services for the elderly and the disabled people who find it difficult to walk and operate the electrical switches to turn on or off the loads, and with the technological development today, modern technologies must be used to help these groups. One of the solutions to this problem is the intelligent systems to control the home appliances. In the existing literature, there are many research papers for different systems and ways working on control the home appliances remotely. We studied several papers and here few of important contributions are presented.

One of the papers that has been published presents a step-by-step procedure of a smart home automation controller. It uses IOT to convert home appliances to smart and intelligent devices, with the help of design control. An energy efficient system is designed that access the smart home remotely using IOT connectivity. The proposed system mainly requires, Node MCU as the microcontroller unit, IFTTT to interpret voice commands, Adafruit a library that supports MQTT acts as an MQTT broker and Arduino IDE to code the microcontroller. This multimodal system uses Google Assistant along with a web-based application to control the smart home. The smart home is implemented with main controller unit that is connected with the 24-hour available Wi-Fi network. To ensure, that the Wi-Fi connection do not turn off, the main controller is programmed to establish automatic connection with the available network and connected to the auto power backup [2]. The optimization of home power consumption based on PLC (Power Line Communication) for an easy to access home energy consumption was presented in [3]. This also proposes a Zigbee and PLC based renewable energy gateway to monitor the energy generation of renewable energies. ACS and DDEM algorithm are proposed for the design of an intelligent distribution of power management system to make sure ongoing power supply of home networks. To provide efficient power management the power supply models of home sensor network are classified groups viz. main supply only, main supply and backup battery, rechargeable battery power and non-rechargeable battery power. Devices with particular features are assigned to these groups. It targets to establish real time processing scheme to address variable sensor network topologies. In [4] the paper focuses on the construction of a fully functional voice based Home automation system that uses Internet of Things, Artificial Intelligence and Natural Language Processing (NLP) to provide a cost-effective, efficient way to work together with home appliances using various technologies such as GSM, NFC, etc. it implements a seamless integration of all the appliances to a central console, i.e. the mobile device. The prototype uses Arduino MK1000, known as Genuino MK1000. The NLP in this project gives the user the freedom to interact with the home appliances with his/her own voice and normal language rather than complicated computer commands. The appliances are connected to the mobile device through an Arduino Board that establishes the concept of Internet of Things. The Arduino Boards are interfaced with the appliances and programmed in such a way that they respond to mobile inputs. Vikram [5] developed a methodology to provide a low cost Home Automation System (HAS) using Wireless Fidelity (Wi-Fi).This crystallizes the concept of internetworking of smart devices. A Wi-Fi based Wireless Sensor Network (WSN) is designed for the purpose of monitoring and controlling environmental, safety and electrical parameters of a smart interconnected home. The different sections of the HAS are; temperature and humidity sensor, gas leakage warning system, fire alarm system, burglar alarm system, rain sensing, switching and regulation of load & voltage and current sensing. The primary requirement of HAS to monitor and control of devices is accomplished using a Smartphone application. The application is developed using Android Studio based on JAVA platform and User Interface of those are exemplified. The primary focus of the paper is to develop a solution cost effective flexible in control of devices and implementing a wide range of sensors to capture various parameters.

We conclude from the previous literature that all research was intended to home automation in different ways. Therefore, in this paper, the proposed system serves as an example of how Android application can be used to create voice-activated home appliances. This system is designed to assist and support elderly and disabled people who have difficulty walking and using electrical switches to turn on or off loads when they are at home. With the help of this system, the user may now simply use voice commands to turn on or off the loads. To show a light, fan, heater, or air conditioner, two loads will be used here. These loads can all be turned ON/OFF individually or together. A Google speech recognition program processes voice input from a smartphone. In this project, the speech input was captured by the Android app and will be sent to the Esp32. The Esp32 accepted the signal and processed it to control the intended load. Through a series of relays, it controls the loads. Between loads and the control unit, relays are utilized. The suggested system was created with an installation- and user-friendly interface to operate electrical appliances.

This work is arranged as follows: Section 2, which is devoted to the block diagram of the system with a brief explanation about the system components. Section 3, covers results and discussion of this work and section 4 of this paper presents the conclusion of the performed work.

System Block Diagram

Figure 1 shows the complete system diagram of the home automation based on voice recognition system and its controller board with one input (Firebase) and three outputs (two relay and buzzer). The Esp32 board was used as the main brain of the whole system; it receives data from the input devices, and then updates the output devices.

The goal of the system is to be able to operate and stop home loads via mobile wirelessly; therefore, the Voice IOT application was designed on android platforms to enable the user to control the loads as required. To complete the communication process between the Esp32 and the phone, the firebase was used to enable the Esp32 board to read the commands sent by the user via the phone. To switch the loads on and off through the Esp32 board after receiving the command from the phone, the relays were used as an intermediary between the low voltages (Esp32 board) and the high voltages (Electrical loads) to enable the system to operate the required electrical load in a safe manner. The purpose of using the buzzer is to generate a sound indicating that the instruction from the phone has successfully reached the Esp32 board. The figure 2 and 3 are shows the prototype of the home automation based on voice recognition in its external and internal shape respectively.

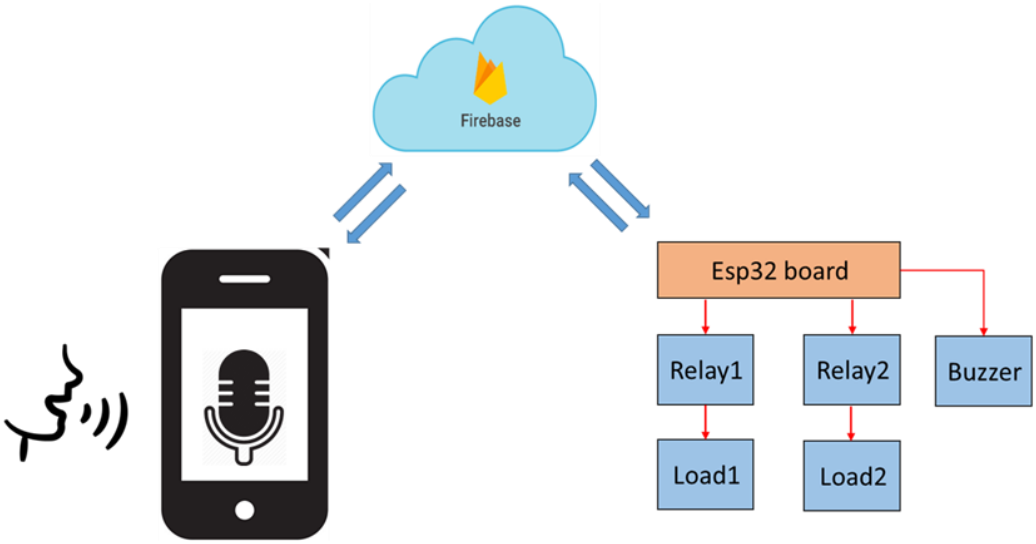

Figure 1: Block Diagram of the Home Automation Based on Voice Recognition System.

Figure 2: External View of the Home Automation Based on Voice Recognition System.

Figure 3: Internal View of the Home Automation Based on Voice Recognition System.

- **ESP32 Board:** The purpose of using the Esp32 board is to receive commands from the firebase and then update the status of the loads based on the user's desire**.**
- **Relay Module:** The relay was used as an electrical insulator between small voltage (Esp32) and high voltages (Loads).
- **Buzzer Module:** The purpose of using the buzzer is to generate a sound indicating that the instruction from the phone has successfully reached the Esp32 board.
- **Firebase:** The purpose of a database is to store data in the cloud so that the user can access the data and control the loads from anytime, anywhere
- **Voice IOP app:** The purpose of the application is to know the user's request when clicking on the buttons and listening to voice commands, after which these commands are sent to the cloud database for execution

Figure 4 shows the cover page of voice IOT application that was designed specifically for this project, this application acts as a point of contact between the user and the home loads. This app is designed on the Kodular platform.

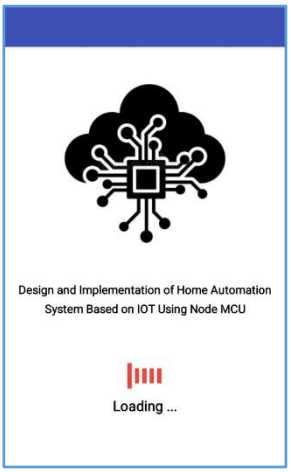

Figure 4: Cover Page of the Voice IOT Application.

After five seconds, another page will open automatically. This page is the control page of the voice IOT application as shown in figure 5. Through which buttons and voice commands can control home loads.

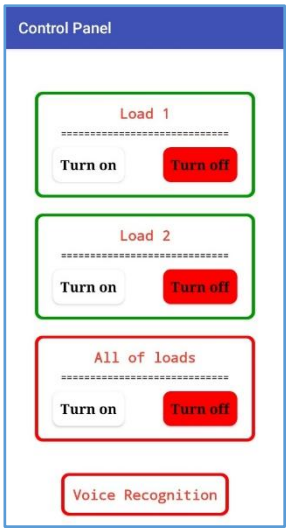

Figure 5: Control Page of the Voice IOT Application.

From figure 5, the control page can be divided into two methods, the first method is to control home loads by pressing buttons and the second method is by voice commands. The commands that will be sent from the voice IOT application to the ESP32 board using the first and second methods are shown in table 1 and table 2 respectively.

Table 1: Transmitted commands for the first method.

User input (click)	Transmitted Command
ON button of load 1	1
OFF button of load 1	2
ON button of load 2	3
OFF button of load 2	4
ON button of all loads	5
OFF button of all loads	6

Table 2: Transmitted commands for the second method.

User input (Voice)	Transmitted Command
Turn on the first load	1
Turn off the first load	2
Turn on the second load	3
Turn off the second load	4
Turn on all the loads	5
Turn off all the loads	6

Results and discussion

The system testing process was divided into several small tests. These tests included the components used in the system separately from each other to verify the readiness of these components, and then they were combined with each other to form the target system. First, the relay module was tested and ensured that it was working properly, then the buzzer module was tested to verify its performance and whether it was free from any malfunctions or not. After that, the main board (ESP32 board) was tested. The test was to send data to the Esp32 unit through the database (firebase) over the Internet and make sure that this data could be received correctly without any loss or significant time delay in receiving it.

Before obtaining the results, we connected the circuit shown in the figure 6. The router was set to generate the Internet name (IOT) with a secret number of the network (1234578) so that the ESP32 board can discover this network and access the Internet. After that, the system was connected to the electric power to start practical experiments as shown in the figure 7.

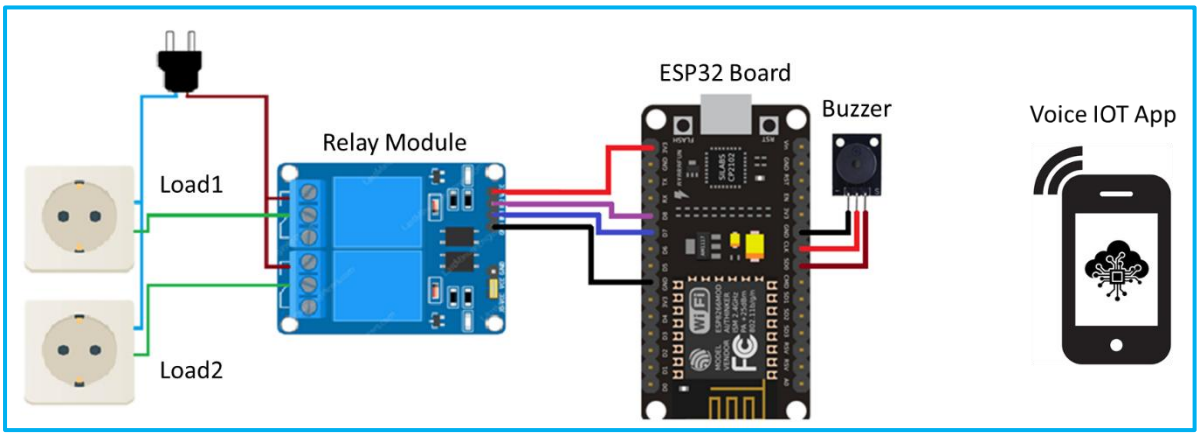

Figure 6: Circuit Diagram of the System.

Figure 7: Electricity Connection to the System.

After that, the voice IOT application is opened in order to start the operation process. When the user presses the ON button for load 1, the voice IOT application sends the command "1" to the firebase. After that, the Esp32 board receives this command through firebase and then operates the buzzer to indicate that the command has been successfully received. After that, the Esp32 board processes the received command and turns on the first load by sending an electrical signal to the relay to deliver electricity to the load to be turned on. The process of switching on the first load by pressing the buttons is shown in figure 8.

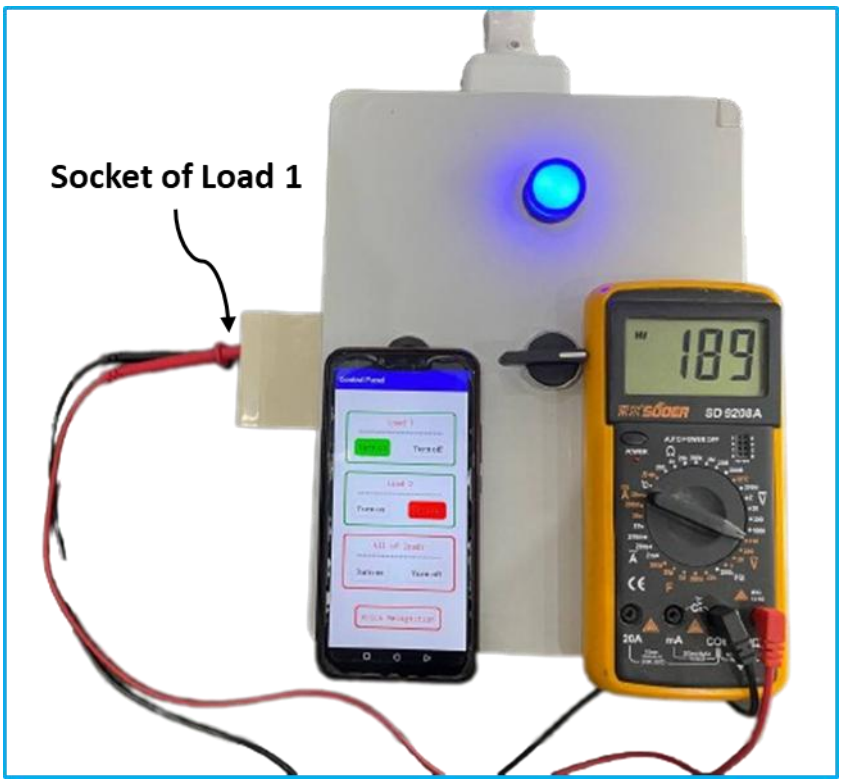

Figure 8: Switching on for the first load-using button in the Voice IOT app.

We notice from the figure 8, that the system received the command sent by the user to operate the first load. After that, the Esp32 board sent an electrical signal to the relay module to connect electricity to the first load. The measured value shows that the voltage is available (189 volts) to operate the house loads successfully. To operate the second load, the same steps as operating the first load must be followed. The process of switching on the second load by pressing the buttons is shown in figure 9.

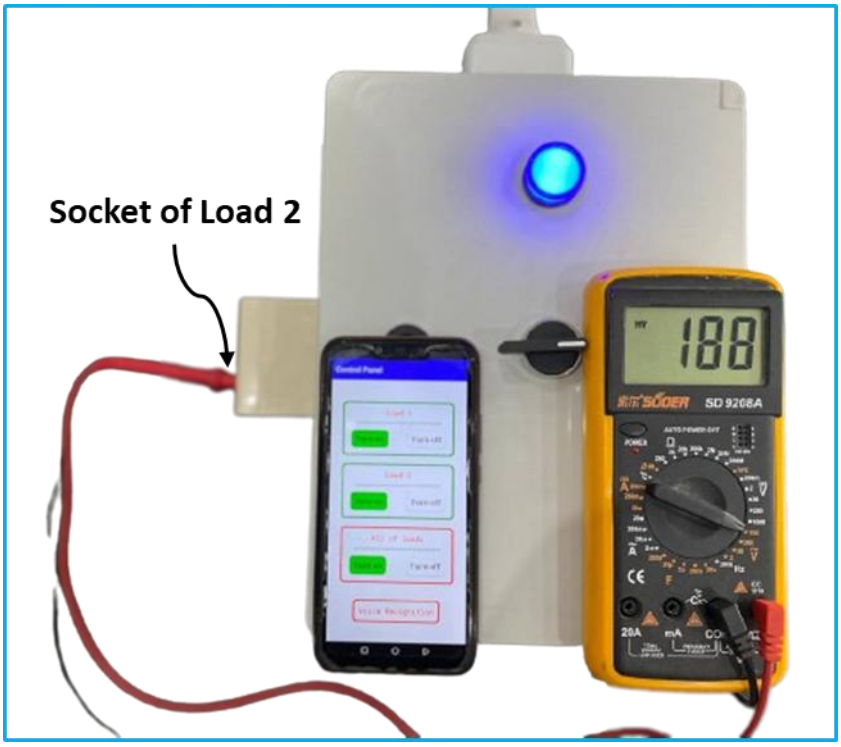

Figure 9: Switching on for the second load-using button in the Voice IOT app.

We notice from the figure 9, that the system received the command sent by the user to operate the second load. After that, the Esp32 board sent an electrical signal to the relay module to connect electricity to the second load. The measured value shows that the voltage is available (188 volts) to operate the house loads successfully.

After completing the steps for running home loads by pressing the buttons via the application. We will explain how to control home loads through voice orders. Through the control page, the voice recognition button is pressed to show the Google tool that converts speech into texts. Then, the user pronounces a set of sentences for this project as shown in table 2 to turn the home loads on or off. Now, all the loads turned on from the previous testing process. As an example to use the voice commands. We must press and hold the voice recognition button. After that, the sentence customized to turning off all loads is pronounced as follows: “Turn off all the loads” and as shown in table 2. After pronouncing the sentence, an order from the voice IOT application will be sent to the firebase stating that what is required is to turn off all the loads. After that, the Esp32 board will receive this command and then, will turn off all home loads at the same time as shown in figure 10.

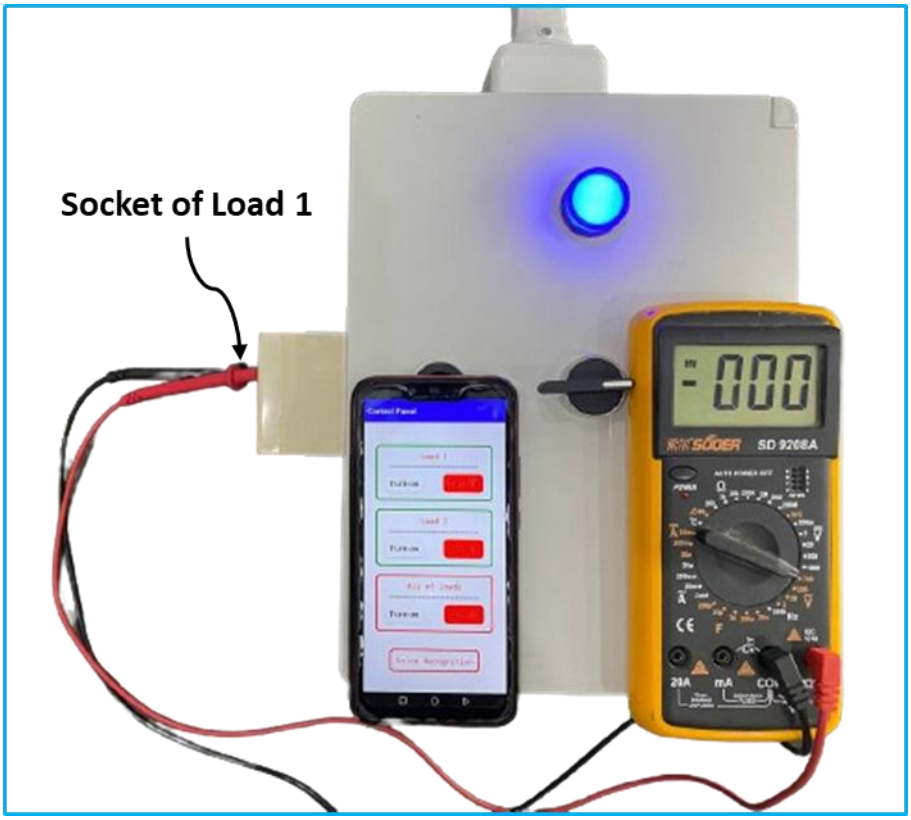

Figure 10: Switching off for all loads–using voice commands in the Voice IOT app.

Through previous practical experiments, through which the system’s capabilities were tested in interacting with the user and implementing the orders sent through it, it can be emphasized that the system succeeded in achieving the required goal at the beginning of the research and was an effective solution to the problems that were previously mentioned.

Conclusion

The home automation based on voice recognition system was successfully designed and implemented based on Esp32 board. The Esp32 board has successfully received the commands sent by the user via android application. In addition, the Esp32 board has successfully updated the status of the electrical loads based on the previously sent commands. The Voice IOT application was able to read the commands to be executed from the user, periodically checking the buttons and voice receiver for quick response and sending the commands to the database (firebase). Google services were used in Voice IOT application to convert the voice into text in order to send it to the Esp32 board. The experimental results show that the user was able to control the home appliances using buttons and voice commands in real time via android application successfully.

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