Research Article

Smart Room Based on ESP32 and Google Assistant: Automation Solution in Electrical Engineering Laboratory Environment

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Abstract: The development of home automation technology and smart rooms is growing rapidly, especially through the utilization of voice commands to control electronic devices. This research develops a voice command-based smart room system using an ESP32 module connected with Google Assistant and the IFTTT platform for device control in an electrical engineering laboratory. The system allows users to turn on or off devices such as lights and TVs with just a voice, improving the efficiency and convenience of laboratory operations. The implementation using ESP32 as a Wi-Fi microcontroller, which activates relays to control devices, was tested in real laboratory conditions that have challenges in the form of electromagnetic interference and noise. The test results showed a fast and accurate system response of up to 90%, although there were some failures in high noise conditions. The system has the potential to be an effective automation solution to support learning and practical processes in electrical engineering laboratories, with further development needed to improve the system's robustness against noise interference.

Keywords: Smart room, Google Assistant, Voice command, ESP32, Home automation

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1. Introduction

The development of home automation and smart room technology[1] is increasingly rapid, one of which is the utilization of voice commands to control devices. In an electrical laboratory environment, the use of this technology can increase efficiency and convenience in managing various existing electronic devices, such as lights, TVs, or other testing tools. ESP 32 Module[2][3], which is known for its ability to connect to Wi-Fi networks, can be used to control these devices by connecting them to a Voice Assistant such as Google Assistant or Amazon Alexa.[4] However, the main challenge in the implementation of this system is the presence of electromagnetic interference and noise in the laboratory that can affect the quality of communication between the devices.

The electrical engineering workshop laboratory is a facility used for practice, experimentation, and testing in the field of electrical engineering. This laboratory serves as a place for students or researchers to understand the principles of electricity, electronics, and control systems through direct practice. This laboratory is very important in electrical engineering education Because it provides direct experience to students in applying the theory they have learned in class, so they can better understand how electrical and electronic systems work in real life. As technology develops, the application of smart voice commands [5] in electrical laboratories allows controlling electronic devices with voice commands, such as turning electronic equipment on or off. This increases efficiency and convenience, as students or instructors no longer need to move around to manually manage devices. The use of this technology is very helpful in creating a more responsive and practical learning environment.

Furthermore, with technology using ESP 32 based on the Internet of Things (IoT) and Google Assistant, [6][7] A voice command-based smart room system can be created for device control in electrical laboratories, which not only saves time and effort but also improves the user experience of interacting with technology in the laboratory.

The application of smart voice in electrical engineering laboratories using ESP 32 based on the Internet of Things (IoT) opens up many possibilities for controlling electronic devices with only voice commands. [8][9] ESP 32 is a Wi-Fi module that can connect devices to the internet and facilitate communication between voice-based devices and other electronic devices. By utilizing the ESP 32 module, the smart voice system can be used to control electrical engineering laboratories such as lights, TVs, or security systems by simply giving voice commands through virtual assistants such as Google Assistant.[10][11]

2. Theory

This Research includes a literature study, system design, hardware and software implementation, and system testing in actual laboratory conditions. The research also evaluates the effectiveness of the system in terms of response time, command accuracy, and user convenience. The results are expected to increase efficiency and comfort in managing devices in electrical engineering laboratories.

Some of the parameters that need to be discussed include systems, components, and several other essential parameters in forming a complete research, which are described in the following definitions: [1] The system is a voice-command-based laboratory space automation, which allows users to control various electronic devices such as lights, TVs, or laboratory tools simply by speaking through Google Assistant.[12], Moreover, [2] The main component of the system is the ESP32 module, which functions as a microcontroller with Wi-Fi connectivity capabilities. The ESP32 receives commands sent through the IFTTT service after the user provides voice instructions through Google Assistant. These commands are then used to activate or deactivate electronic devices connected to the ESP32 through relay modules.[13]

In addition, the system takes into account typical laboratory conditions such as electromagnetic interference and noise, which may affect voice command performance. Therefore, the design and implementation were carried out considering the connection stability and reliability of communication between the devices. [3] A smart room is a room equipped with automation systems and smart technology that allows various electronic devices in it to be controlled automatically, remotely, or through voice commands, apps, and sensors. This concept is part of the implementation of the Internet of Things (IoT), where devices are interconnected through a network and can communicate with each other in real time. Inference Engine: Applies Mamdani-type inference to evaluate rule strength.[14], Furthermore, [4] Smart voice is a technology that enables devices to recognize, process, and respond to human voice commands intelligently. This technology is often applied to devices such as virtual assistants, such as Google Assistant, and other smart devices. In general, smart voice enables more natural and easier interactions between humans and technology and changes the way we interact with devices daily.

2.1 Hardware Specifications

The following are the specifications of the ESP32 Microcontroller, among others:

Table 1. Tool Specifications

Name	Specifications
Processor	Dual-core Xtensa 32-bit, up to 240 MHz
Memory	520 KB SRAM, 4 MB Flash (common)
Wi-Fi	802.11 b/g/n
Bluetooth	Version 4.2 (Classic + BLE)
GPIO	Up to 34 input/output pins
ADC	12-bit, up to 18 channels
DAC	2 channel
PWM	Available in many pins
Communication	UART, SPI, I2C, I2S, CAN
Built-in sensors	Hall effect sensor, temperature sensor
Working voltage	3.0 - 3.6 V (generally 3.3 V)

2.2 Working principle of ESP32 microcontroller

The ESP32 functions by receiving data from sensors, processing it according to the program it runs, and then sending the output to devices such as lights, displays, or via the internet. The microcontroller also supports Wi-Fi and Bluetooth connections and has a power-saving feature for energy efficiency.[15] One of the free software that can be downloaded is Blynk. Blynk is an IoT (Internet of Things) platform that allows users to create mobile applications to control electronic devices via smartphones. Blynk provides a user-friendly graphical interface to connect and control ESP32 devices using Wi-Fi, Bluetooth, Ethernet, or other internet connections. [16] This platform has various applications, especially in smart room systems that utilize the ESP32 as a microcontroller.

Figure 1. Blynk App (Sources: https://blynk.io/)

Moreover, each of the parameters ranging from End-nodes, Gateways, and Internet Servers, as well as Application Servers are summarized in a basic understanding, i.e., the Internet of Things (IoT) Principle. The Internet of Things (IoT) is an advanced technology designed to extend and enhance the benefits of continuous Internet connectivity. This concept allows various objects around us to be interconnected, making daily activities

easier and more efficient. With IoT, various human tasks and jobs can be done more practically, automatically, and integrated, thereby increasing convenience and productivity in various aspects of life. IoT is closely related to Big Data, Specifically, the 4 components of Big Data that need to be known are shown in Figure 2. The relationship between IoT and Big Data, as well as another component, Artificial Intelligence, can be seen in Figure 3.

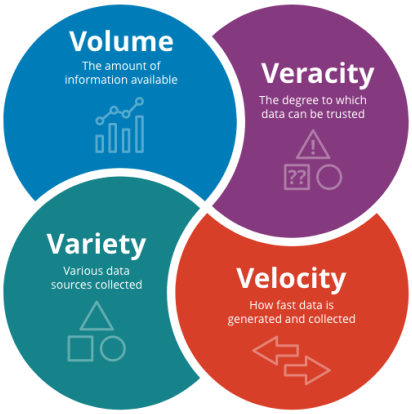

Figure 2. Big Data Component (Sources: https://efficientlearning.com)

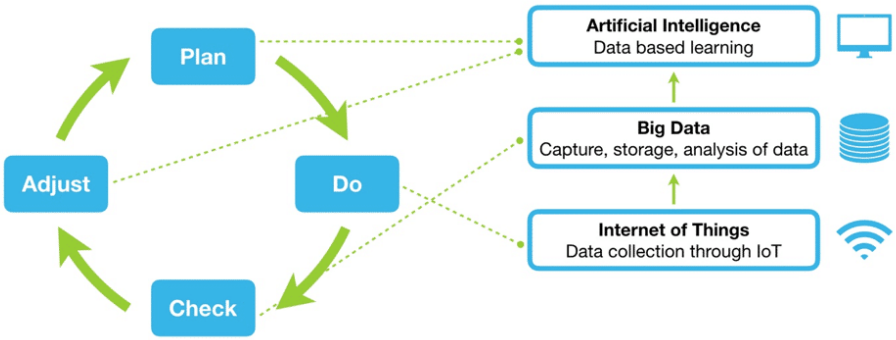

Figure 3. The close relationship between IoT and Big Data (Sources: https://arviem.com/)

The term Internet of Things (IoT) consists of two main words: Internet, which serves to connect and organize connectivity, and Things, which refers to objects or devices. In simple terms, IoT allows various devices (Things) [17][18] to connect, collect, and transmit data to the internet. The collected data can also be accessed by other devices, where each specific device has the ability to transmit information over the network, anytime and anywhere. This process takes place automatically without requiring direct human-to-human or human-to-computer interaction.[19]

Furthermore, IFTTT (If This Then That) is an automation platform that enables the integration of various devices and services without the need to write complex programming code. In the smart voice ecosystem, IFTTT serves as an intermediary between voice assistants such as Google Assistant."[20] With voice commands, users can control laboratory devices, automate various tasks, synchronize services that do not have direct compatibility, and improve convenience and efficiency in daily life.

Figure 4. IFTTT (If This Then That)

IFTTT (If This Then That) in smart rooms offers a highly efficient solution to automate and connect various smart devices in the room. Using IFTTT [Figure 4], these devices can communicate with each other and work in a coordinated manner, creating a more comfortable, efficient, and safe environment. IFTTT enables smart rooms to be more integrated, practical, and responsive. Users can easily control various devices such as lights, temperature, music, and security systems by creating simple rules. All systems in the home can operate automatically according to preferences, routines, or environmental conditions, creating a smarter, easier, and more customized experience.

3. Method

This research aims to design and implement a voice command-based smart room system using ESP32, Google Assistant, and the IFTTT platform to control electronic devices in electrical engineering laboratories automatically. The system that is built can be seen in Figure 5, namely the following System Block Diagram.

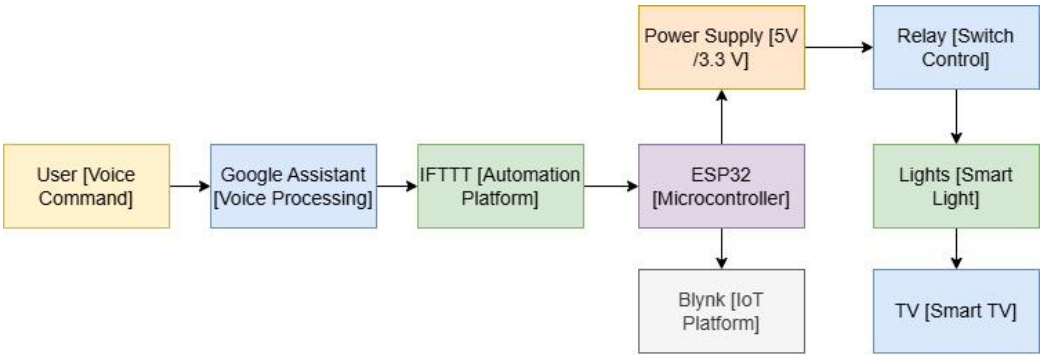

Figure 5. System Block Diagram or Smart Home Control System

This image shows how a smart room system works that uses voice commands to control electronic devices such as lights and TVs. The user gives voice commands through Google Assistant. The command is forwarded to IFTTT and then sent to the ESP32. The ESP32 is a device that controls the system and is connected to the internet. The ESP32 then activates the relays which function like an automatic switch. If the relay is active, the lights or TV will turn on. The ESP32 also gets power from a power supply and can be monitored or controlled via the Blynk app on a smartphone. With this system, users can control electronic devices with just their voice or through an app, making it more practical and efficient.

Furthermore, Figure 6 shows the flowchart or workflow of the voice command-based smart room system. The process starts when the system is powered on and the device is connected to the internet network. After that, the system performs initialization to prepare all components to be ready to receive commands. Then, Google Assistant will listen to voice commands from the user. If no command is received, the system will

continue to wait. However, if the command is received, it is forwarded to the IFTTT service, which then sends the command to the ESP32 microcontroller. After receiving the command, the ESP32 will check if the relay is active. If the relay is active, then the device such as a lamp or TV will turn on. Once the device successfully turns on, the process is considered complete. This system allows automatic control of devices using only voice, making it more practical and efficient.

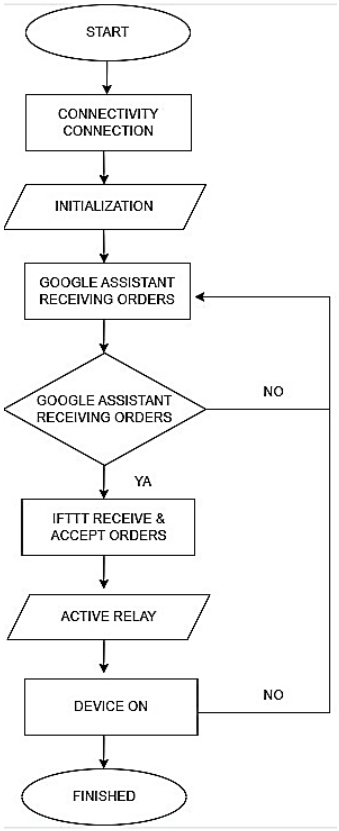

Figure 6. System flowchart

4. Result and Analyzes

4.1 Device Control Using Google Assistant

The following is an example of data in the form of a table that illustrates the use of Google Assistant in a smart room system to control electronic devices using voice commands, Table 2 shows the test results from Control using Google Assistant.

Table 2. Control using Google Assistant

No	Voice Commands (Google Assistant)	Controlled Devices	Device Status	Execution Time	System Response
1	" Turn on the light"	Lights	ON	8:15:10	Order received
2	“Turn off the lights”	Lights	OFF	8:20:03	Order received
3	"Turn on the TV”	TV	ON	8:30:55	Order received
4	"Turn off the TV"	TV	OFF	8:45:22	Order received
5	" Turn on the front room lights"	Front Room Light	ON	9:00:12	Order received
6	" Turn off all devices "	Light, TV	OFF	9:30:45	All devices OFF
7	"Turn on all devices"	Light, TV	ON	10:05:00	All devices OFF

4.2 Smart Room System Testing Results

The following is an example of a table of test results of a voice command-based smart room system using Google Assistant, IFTTT, and ESP32, which includes testing connectivity, device response, and command accuracy. Table 3 is the specific results of the system testing.

Table 3. Testing System

No	Tested Components	Test Scenario	Expected Results	Testing Results	Status
1	Internet Connection	Check if ESP32 can connect to Wi-Fi	ESP32 successfully connected	Successful	Compliant
2	Google Assistant	Say "Turn on the light"	Google Assistant recognizes voice	Recognized	Compliant
3	IFTTT	Send command from Google Assistant to ESP32	IFTTT sends Webhook to ESP32	Successful	Compliant
4	ESP32	Receive command from IFTTT	ESP32 processes command	Successful	Compliant
5	Relay Module	Check if the relay activates after the command received	Relay turns on	ON	Compliant
6	Lights	Say "Turn on the light"	Lights turn on	ON	Compliant
7	TV	Say "Turn on the TV"	TV turns on	ON	Compliant
8	Blynk App	Control devices via Blynk	Lights/TV respond	Functioning	Compliant
9	System Time Response	Calculate the time from command to	< 3 seconds	±2.5 seconds	Compliant
10	Sounds in the Environment	device activation	Command still recognized	Multiple failures	Not Compliant (interference)

4.0 Conclusion

The system that integrates IoT and voice command technology in the electrical engineering laboratory or smart room has achieved a success rate of 90%, indicating that the system can be implemented functionally and effectively. This proves that the use of this technology can improve the efficiency of operating devices automatically with voice commands. However, there are still challenges related to the system's resistance to noise or sound disturbances in the surrounding environment that can affect the accuracy of command recognition. Therefore, further development is needed to improve the system's ability to filter out sounds to remain reliable in various environmental conditions. With these improvements, the system is expected to become a more optimized and reliable automation solution in supporting activities in laboratories and smart workspaces.

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