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Automatic Control of Lights in a Room Using IoT-Based PIR Sensor

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ABSTRACT

Objective: *Technological innovations facilitate digital operation, exemplified by smarthome technology. This study aims to implement this technology in a prototype for light control using a PIR sensor.* ***Method:*** *The research adopts a research and development approach, conducting tests on the ESP32 microcontroller, PIR sensor, four-channel relay, and Blynk application-controlled lights.* ***Results:*** *Results indicate that the PIR sensor effectively detects objects within a range of 30cm to 1m. The four-channel relay successfully regulates the on/off functionality of the connected lights. Command execution from the Blynk application button exhibits an average delay of 1.1 seconds for light activation via smartphone. Testing of the PIR sensor indicates an effective object detection range of up to 5m, triggering automatic light activation when the user is within this distance.* ***Novelty:*** *Technological innovations facilitate digital operation, exemplified by smarthome technology.*

INTRODUCTION

The human desire to constantly innovate, particularly in the field of technology to simplify daily activities, is developing very rapidly today across various strategic sectors, both upstream and downstream [1], [2]. In the industrial automation sector, technological advancements can be seen in the application of electronic equipment control systems [3], [4]. Initially, control systems used switches to manually cut off the electrical current, but now they use a centralized system that can control the switches from a single location [5].

By applying this scheme to a smaller scale, namely the household environment, a technology called a smart home was born [6]. Smart homes allow residents to control the on and off of household appliances such as lights and fans using a smartphone, thereby increasing comfort, security, and energy savings for residents. Several previous studies on smart homes have been written, including research by Dewi Lestari (2021), where the researcher created a special smart home device for people with neurological disorders, allowing devices like lights, fans, and TVs to be easily controlled even if the user has physical limitations, using electrooculogram signals and controlling with the eyes [7].

Then, research by Adie Pratama Putra (2023) on the application of fuzzy logic to control lamp brightness using an Arduino microcontroller equipped with an automatic AC light dimmer. The test results show that the device can control the light intensity in three conditions: bright, dim, and off [8].

Finally, research by Ifnu Akbar Rupianto (2023), where a smart home device was created using an ESP32 microcontroller and equipped with a control device in the form of an Android application connected via Bluetooth. Users can monitor current, voltage, and power values in real-time via a smartphone. The device can also control the lights turning on and off through button input in the smartphone application [9].

This current research will implement smart home technology into a complete system to control home devices such as lights, which can be easily monitored and controlled according to the residents' wishes using their smartphones connected to the system via the Internet of Things protocol. The research uses the ESP32 microcontroller as the program's processing center and the link between the devices and the smartphone, utilizing the ESP32's capability to connect to the home Wi-Fi network [10], [11]. Monitoring and controlling smart home devices will be done through the Blynk application, which has been installed on the residents' smartphones [12]. The sensor used is a PIR sensor for object detection [13]. The control of the four lights is managed using a 4-channel relay [14].

RESEARCH METHOD

The research utilizes a research and development method by testing the effectiveness of the tool thru various experiments, improvements, and finalization of the tool in order to overcome the problems faced and achieve the final goal where the product functions according to the research objectives [15]. The stages in the research and development method are problem identification (1); literature review (2); design (3); testing (4); improvement (5); and implementation (6).

A. Block diagram

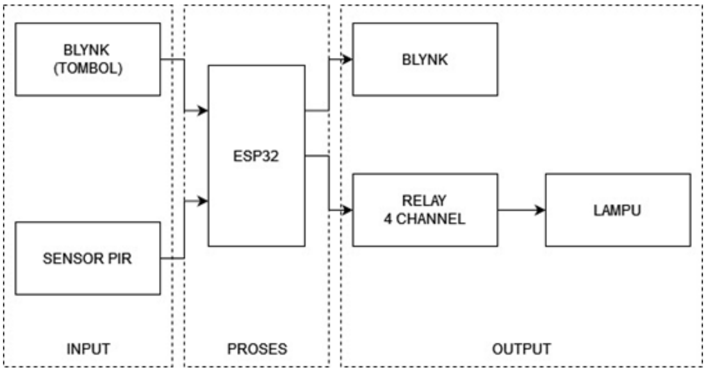

Figure 1. Block Diagram.

The research utilizes an AC-to-DC converter module as a 5V voltage input to the ESP32 and a 220V voltage to the controlled lamp. Then there is the PIR input as an object detector within the smart home. The data from the PIR sensor readings is processed by the ESP32 microcontroller. The output components are the Blynk application interface installed on the user's smartphone and a 4-channel relay that controls the on and off states of the four lights in the smart home.

B. Flowchart

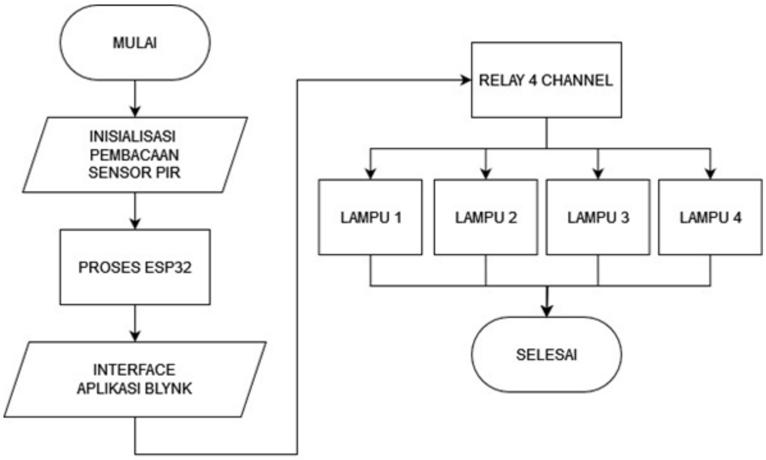

Figure 2. Flowchart.

The flowchart explains the stages of the system's process or a graphical representation of the stages of a program. The flowchart stages begin with data input from the initialization of the PIR sensor reading, which is then processed by the ESP32 microcontroller. The sensor reading results are then displayed on the Blynk application interface installed on the user's smartphone. While connected to the internet network, users can monitor the condition of their home and control the lights using button command inputs in the Blynk application. The input from this button is then translated into high and low logic on a 4-channel relay connected to four lights.

C. Wiring Diagram

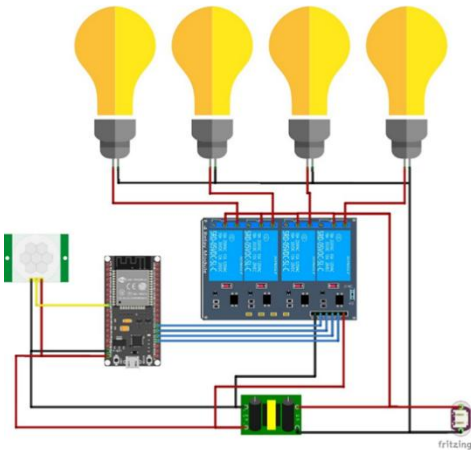

Figure 3. Wiring Diagram.

As seen in the image above, the ESP32 microcontroller is the central component of the wiring diagram design. The system is powered by a power supply that supplies AC current, which is then converted to DC current for the ESP32 and the 4-channel relay. Pins IN1 to IN4 of the 4-channel relay are connected to GPIO4, GPIO0, GPIO2, and GPIO1 of the ESP32 to control the lighting of electronic devices, such as lamps, that are connected to the relay in a Normally Open (NO) configuration. The PIR sensor is connected to the GPIO25 pin of the ESP32.

RESULTS AND DISCUSSION

A. Actual results of the tool

Figure 4. Results of Tool Realization.

The realization of the device, as seen in the image above, shows the appearance of a smart home prototype where there is a PIR sensor at the front and electrical circuits inside, such as an ESP32 microcontroller, a four-channel relay, and four lights to illuminate the house.

B. PIR sensor testing

PIR sensor testing is conducted to test the sensor's capability in detecting objects in front of it, as well as the effective angle and distance range of the PIR sensor.

Figure 5. View of the PIR Sensor Installed on the Device.

The image above shows the condition of the PIR sensor installed on the front side of the house, allowing the sensor to detect human objects approaching the entrance.

Table 1. Testing of PIR Sensor Detection Distance.

Test No.	Distance	Object Detected	Lamp Condition
1	30 cm	YES	ON
2	50 cm	YES	ON
3	100 cm	YES	ON
4	150 cm	YES	ON
5	200 cm	YES	ON
6	300 cm	YES	ON
7	400 cm	YES	ON
8	500 cm	YES	ON
9	550 cm	NO	OFF
10	600 cm	NO	OFF

The test results on the PIR sensor show that the sensor functions with a distance range between 30cm and 500cm in detecting objects in front of it, allowing the sensor to automatically activate the lights within that range. However, there is a limitation on the sensor's reading distance, as objects more than 550cm away cannot be detected, causing the sensor to remain inactive.

C. Testing data transmission to the Blynk application

Testing the transmission of instrument reading data to the Blynk application is intended to determine the delay between reading time and transmission.

Table 2. Data Transmission Testing to the Blynk Application on User Smartphones.

Test No.	Data Transmission	Waiting Time (s)	Response Speed
1	SUCCESSFUL	1.2	FAST
2	SUCCESSFUL	1.1	FAST
3	SUCCESSFUL	1.0	FAST
4	SUCCESSFUL	1.3	FAST
5	SUCCESSFUL	1.1	FAST
6	SUCCESSFUL	1.0	FAST
7	SUCCESSFUL	1.1	FAST
8	SUCCESSFUL	1.3	FAST
9	SUCCESSFUL	1.2	FAST
10	SUCCESSFUL	1.1	FAST
Average delay		1.1	

Table 2 shows that the average delay between the commands given by the user via smartphone and the data received from the Blynk application is 1.1 seconds, which is considered fast, making it easy for users to obtain real-time data with sufficient accuracy.

Figure 6. Delivery Delay Testing Graph.

D. Testing the Bynk application

Testing was conducted on the Blynk application that had been modified and installed on the user's smartphone. In this application, there is one core widget used, which is a button, of which there are five. The top four buttons are used to control the light, while the bottom button is used to control the PIR sensor.

Figure 7. Blynk Application Interface.

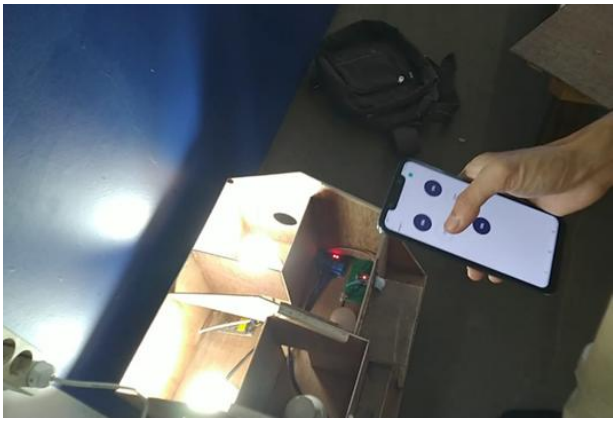

Figure 8. Blynk Application Demo View.

The demo of using the Blynk application, as shown in the image above, demonstrates that when the user presses two buttons in the Blynk application, two lights automatically turn on, while the other two lights remain off. This indicates that the application is functioning correctly.

CONCLUSION

Fundamental Finding : The technological developments applied in the smart home concept in this study bring a unique convenience in providing comfort to users thru controlling the lights, whether by sending commands from a smartphone or thru object detection by a PIR sensor. **Implication :** The technological developments applied in the smart home concept in this study bring a unique convenience in providing comfort to users thru controlling the lights, whether by sending commands from a smartphone or thru object detection by a PIR sensor. This finding implies that smart home–based lighting control systems can enhance user comfort and operational efficiency by combining manual control via mobile applications and automatic control based on sensor detection. **Limitation :** The technological developments applied in the smart home concept in this study bring a unique convenience in providing comfort to users thru controlling the lights, whether by sending commands from a smartphone or thru object detection by a PIR sensor. However, this study is limited to a prototype-scale implementation and focuses only on lighting control, without evaluating long-term system reliability, energy consumption efficiency, or user behavior in real residential environments. **Future Research :** The technological developments applied in the smart home concept in this study bring a unique convenience in providing comfort to users thru controlling the lights, whether by sending commands from a smartphone or thru object detection by a PIR sensor. Future research may expand this system by integrating additional smart home components, optimizing sensor sensitivity and response time, and conducting large-scale testing to assess usability, scalability, and energy-saving potential in real-world applications.

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