Developing application of automatic lamp control and monitoring system using internet of things

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Abstract. This research aims to build a prototype of an automated light control and monitoring system based on internet of things. This system controller uses Wemos D1 microcontroller with integrated ESP8266 Wi-Fi module, which functions to send and receive input data on the Internet of Things (IoT) platform, namely Firebase. Input devices in this system are in the form of two types of sensors namely the LDR sensor and the PIR sensor where the LDR sensor functions as a measure of light intensity and the PIR sensor functions as a detector of human motion in a room. This system uses 2 lamps as an output device, where the lamp is placed in a clear plastic box formed as a room. In room 1, the lamp will turn on if a human presence is detected. In room 2, the lamp will turn on if the room's lighting conditions are dim or dark and a human presence is detected. In addition, the control and monitoring system of this lamp can also be controlled via the android application without a certain distance and only requires an internet connection.

1. Introduction

Electrical energy is one of the most important human needs and cannot be separated from daily needs. If the available electrical energy is insufficient, it can disrupt human activities. This is inversely proportional to the limited supply of electrical energy sources, where currently Indonesia is still very dependent on coal as a source of electrical energy. It should be remembered again, coal is a resource that comes from fossil energy which is not renewable. In Indonesia, the need for electrical energy is increasing over time along with the increasing population. Data from the Indonesian Central Bureau of Statistics informs that the total population of Indonesia in 2012 reached 245 million, or increased by 1.51% per year since 2000 [1]. This will certainly affect the level of energy demand, especially electricity. According to the Indonesian Minister of Energy and Mineral Resources (ESDM), Ignasius Jonan, said Indonesia's electricity consumption has continued to increase every year, since 2014 amounted to 878 kWh per capita, then in 2015 it was 918 kWh per capita, 2016 amounted to 956 kWh per capita. The figures have increased again in 2017 by 1,012 kWh per capita and 2018 by 1,064 kWh per capita[2]. As a result, it is not surprising that in the end the basic electricity tariff continues to increase considering the decreasing supply of fossil energy. Saving electrical energy has now become a common topic discussed in various circles of society. The use of electrical energy outside of necessity is still a popular culture, such as living lights, but there are no residents in the room. The automatic control system has a very important role in technological development. And it can replace the usual routine and boring work that humans have to do. Gadgets are very helpful for making work easier for those who require very high mobility, for example; laptops or portable computers, tablet PCs, Android smartphones and so on. Nowadays, many electrical devices work integrated with computer systems.
Internet of Things (IoT) is a technology that can connect an equipment to the Internet to carry out various functions [3]. The concept of IoT is very helpful in the process of remote control via an Smartphone Android. This IoT system can be applied to create an automatic control system that can be controlled and monitored via gadgets. Based on the above background, in this research the writer will compile and make a prototype tool entitled "Automatic Light Control and Monitoring System Based on IoT (Internet of Things)". This tool functions as a switch that can be controlled via an Android-based application. This tool also has a sensor that can turn the lights on when someone is in the room and will turn off when the room is empty.

2. Literature Review

Research about Ambient Light Control System Automatically Using PC-Based Microcontroller Arduino Uno. In this research, the system of a room light controller was carried out automatically, the design of the tool used the Arduino Uno as a microcontroller using the Arduino IDE program based on the C language [4]. The similarity of this study with the one that the author is careful about is programming using Arduino IDE but for the microcontroller the author uses the Wemos D1 ESP2688.

"Bathroom Light Control Model Using Passive Infrared Receiver Sensor Based on Arduino Uno". In this study, the design of a tools to control bathroom lights was carried out using the Arduino Uno as a microcontroller and a Passive Infrared Receiver (PIR) sensor as a motion detection sensor. The sensor is installed in the bathroom and points downward with a maximum distance of approximately 6 meters. It was explained that if someone enters the bathroom, the light will turn on with time (1 minute), and the light will turn off after the set time has elapsed without having to turn off the switch [5]. The similarity between this study and the one that the author examined is the PIR sensor used to detect motion, but for the microcontroller the author uses the Wemos D1 ESP2688.

"Smart Home Application Based on Android with Arduino Microcontroller". In this research, an application system with a smart home concept was designed, this system is used to control electronic equipment such as lights. The system uses the Arduino Uno as a microcontroller and uses a Bluetooth module as a communication medium with the microcontroller. It is explained that the maximum distance from this wireless connection module is approximately 10 meters. The light switch system in this tool is replaced by using a relay device and is controlled through a network-based microcontroller device so that it can be connected to a smartphone that has a smart home controller application installed [6]. The similarity of this study with that of the author is in terms of the control media using Android, but for the microcontroller the writer uses Wemos D1 ESP2688.

"Utilization of the Internet of Things at Light Control". In this study, the design of a device with the concept of the Internet of Things (IoT) was carried out using the Arduino Uno as a microcontroller and a light sensor that is used to detect changes in light intensity received. Wireless ESP8266 is also used as a WiFi module which functions as a communication medium, so that the Arduino Uno microcontroller can connect directly to WiFi and make a TCP / IP connection [7]. The similarity of this study with the one that the author examined is the concept of the Internet of Things which uses an LDR sensor to detect light intensity, but the microcontroller that the author uses is slightly different from the research, namely using Wemos D1 which is a built-in WiFi module. ESP8266.

"Design of Student Attendance System Using Internet of Things (IoT) Technology". In this research, the system was proposed to reduce the level of fraud in filling the attendance list and effectiveness of student data processing using a system of applying the concept of the internet of Things (IoT) with the fingerprint presence method [8]. The similarity of this study with the one that the author is careful about is using Internet of Things (IoT) concept.

"Design of Product Monitoring System Using Internet of Things Technology for Smart Manufacturing". In this study discussed the design of a monitoring system on smart manufacturing based on internet of things technology. Smart technology is implemented on material scans automatically based on color sensors, then from the material it will also be known that with these materials produce certain products and require any material [9]-[11]. The similarity the system can running automatically based on sensors and system Internet of Things (IoT).
3. Research Methods

IoT-based automatic light control and monitoring system aims to make it easier for humans to control and monitor lights, this tool system also functions as a substitute for conventional household switches. As for making this tool system using data collection methods in order to find data and information in order to achieve the goal of making this tool system. It also explains the stages of designing the tool and making the application. Before designing the automatic light control and monitoring system, data was collected from the library and looked for references from various journals.

3.1. Data Collection Methods

To achieve the desired objectives, data collection activities include literature studies, namely searching and collecting literature and studies related to the problems that exist in this final project, both in the form of articles, reference books, data from the internet, and other sources related to the problem of the final project. In addition, the authors also use the observational project method, which is a method that is carried out directly observing how the existing management process is used as material for the researcher in making the final made.

3.2. Design Block Diagram

Diagram of a system, as seen in Figure 1, where the main part or function is represented by blocks connected by lines indicating the relationship of the blocks. This block diagram is an overview of how this tool system works. This automatic light control and monitoring system consists of an input device and an output device. The Wemos D1 microcontroller manages input and output devices, the ESP8266 WiFi module is used for Wemos D1 communication with the Cloud Webserver as a place to store data so that it can be controlled via an android device remotely. This system has two control system modes, namely automatic mode and manual mode. Mode selection can be made via the application interface on an Android smartphone.

![System Block Diagram](image)

**Figure 1.** System Block Diagram
3.3. Flowchart System

This system starts with Wemos D1 connecting to the internet via the ESP8266 WiFi Module to send and retrieve data to the cloud server, then Wemos D1 performs data retrieval to the cloud server to find out which mode to use. When manual mode is selected, the tool waits for the cloud server to turn on / off the lights where the cloud server gets data from an Android application controlled by the User. While the auto mode, which will retrieve data from the PIR sensor and LDR sensor, then sends the data which will be forwarded to the relay to turn on the light. After the lamp status changes, data will be sent back to the server to be displayed on the Android application. The microcontroller flowchart is presented in the Figure 2.

![Flowchart System](image)

**Figure 2.** Flowchart System

3.4. Interface Design

The design of this system interface design describes the appearance of the system which will be created after implementation. The design of the IoT-based Automatic Light Control and Monitoring System Application interface is as follows.

The main menu display design is to display the initial appearance when the application is opened, as described in Figure 3. There is a Switch button mode to choose which mode to use, namely manual mode or auto mode. Then below it is the current mode status followed by the "GO" button at the bottom to enter the selected mode page. auto mode is a mode taken from the sensor, namely the PIR sensor and the LDR sensor, in this mode the user can only monitor the ON / OFF condition of the lamp. Whereas manual mode is a mode for controlling the ON / OFF of the lights from this application page, in this mode the user can also monitor the ON / OFF condition of the lamp.
Figure 3. Design of Main Menu

Figure 4 shows auto mode menu page displays 2 lamp images, namely lamp 1 and lamp 2 which function as indicators as well as the ON / OFF status at the bottom of the lamp image. Users can only monitor the lights without being able to control them because they use the PIR sensor and the LDR sensor as input.

Figure 4. Design of Auto Mode Menu Page

Figure 5 shows manual mode menu page section that used by the user to control and monitor lights. There are two indicator lights and two switch buttons. The lamp indicator is used to determine the ON / OFF condition of the lamp, if the light is on, the indicator will be bright, and vice versa if the light is off then the indicator will be dark and there is a switch button which functions as to control the ON / OFF of the lamp.

Figure 5. Design of Manual Mode Menu Page

3.5. Hardware Design

Figure 6 shows the design that describes the layout of the control system and automatic light monitoring that will be made.
4. Results and Discussion

Application control and monitoring system based automated lights IOT is expected to alleviate human tasks in the control of lighting. With this system users can switch from manual control from conventional switches to automatic control. The system of this tool works in two modes, namely auto mode and manual mode. In auto mode this system works based on sensors as input data from the system of this tool, then for manual mode, this system will work based on applications on Android as input data from the system of this tool.

4.1. Hardware Implementation

This automatic light control and monitoring system is designed with a variety of hardware in order to build a control system and automatic light monitoring that can work as expected. The hardware used and as a link with the application is Wemos D1. This microcontroller is the central brain for processing all the tools in this system. Wemos D1 is used to send data to applications obtained from sensors that are interconnected with various hardware other, as described in Figure 7.

Relay module is used as a substitute for a conventional switch to be automatic with the Wemos D1 microcontroller. Relay module as the main switch for room lights, where the current uses AC current and the control system uses DC current. Figure 8 shows relay module as an automatic AC current switch from a DC current source.
PIR sensor is an infrared-based sensor that is used to detect motion, in this case it functions to detect the presence of people in the room. The PIR sensor will signal into the Wemos D1 system when it detects motion. In this tool system using 2 PIR sensors, which shows in Figure 9. In the first case, the PIR1 sensor is used to detect movement in room 1. If the PIR1 sensor detects movement, then lamp 1 in room 2 will light up. In the second case, the PIR2 sensor is used to detect movement in room 2. However, in the case of room 2 it also uses the LDR sensor, so the light will turn on if the LDR sensor detects dim/dark light and the PIR2 sensor detects motion.

LDR is a type of resistor whose resistance value depends on the intensity of the light it receives. This sensor is used to measure the intensity of light received, the LDR sensor will provide a value for the intensity of the light received into the Wemos D1 system. LDR sensors are placed in the light fitting section, as seen in Figure 10. The placement of the sensor in this section is intended so that the sensor can measure the light intensity in the room accurately.

4.2. Software Implementation

Application in the automatic light control and monitoring system is used in order to be able to control this tool remotely via smartphone android.
Figure 11. Interface of Main Menu

Figure 11 on this main menu display there is a switchbutton mode which functions to switch to using auto mode or manual mode. And there is also a state mode that is currently in use, where the value of the mode state is taken from the Firebase cloud database that was previously created. In the lowest position there is a button GO which functions to enter the next page, if the switchbutton in auto mode then when the button GO pressed it will be switched to the auto mode page, likewise if the switchbutton mode is in manual mode it will be switched to the manual mode page. Auto mode is a system mode using input data from sensors to control the lights automatically. Manual mode is a system mode using this application as input data to the system to turn a lamp on and off.

Figure 12. Interface of Auto Mode Page (a)  Figure 13. Interface of Auto Mode Page (b)

Figure 12 on this auto menu display there are 2 lamp indicators, namely for lamp 1 and lamp 2. This indicator will be bright and the status is ON if the database shows the value 1, and vice versa if the database shows value 0 then the light indicator will be dark and the status is OFF.

Figure 13 on this manual menu display there are 2 lamp indicators, namely for lamp 1 and lamp 2 along with the switch button ON / OFF below. If the selected switch button is ON, the light indicator will be yellow and vice versa if the selected switch button is OFF, the light indicator will be dark. In this mode the user can control the ON / OFF of a lamp because in this mode the system will be using this application as input data to the system to turn a lamp on and off.
4.3. Testing Tool System

Testing of this tool system is done to find out how the tool fits its function and to find out the main function of the tool, namely as a control system and automatic light monitoring based on internet of things. The results shown at Table 1 and Table 2.

| Value PIR1 | Value LDR | Value PIR2 | Output Lamp 1 | Output Lamp 2 |
|------------|-----------|------------|---------------|---------------|
| 1          | 1         | 1          | ON            | ON            |
| 1          | 1         | 0          | ON            | OFF           |
| 1          | 0         | 1          | ON            | OFF           |
| 1          | 0         | 0          | ON            | OFF           |
| 0          | 1         | 1          | OFF           | ON            |
| 0          | 0         | 1          | OFF           | OFF           |
| 0          | 1         | 0          | OFF           | OFF           |
| 0          | 0         | 0          | OFF           | OFF           |

In testing the auto mode tool system, it can be seen that the system can work based on input data from PIR1 for lamp 1 output in room 1 while for output in room 2, namely lamp 2, it depends on input data from the LDR sensor and PIR2 sensor. The PIR sensor has a low active condition, namely the condition where there are no people, the digital value is 0 and the condition is that there are people, the digital value = 1. As for the LDR sensor, the writer uses a potentiometer to adjust the light intensity limit with the logic of light conditions, the digital value = 0 and dark conditions The digital value = 1. In testing Table 1. It explains that when the system reads PIR1 is 1, the system will perform an order to turn on lamp 1 which is the output in room 1 and vice versa when PIR1 is 0 then lamp 2 will turn off. where this condition occurs in room 1. As for room 2, the system will only turn on lamp 2 when the value of the LDR sensor = 1 and PIR2 = 1. If the two sensors are not worth 1 then lamp 2 will turn off. In addition, seen from this test it also explains that this system can work in a manner multitasking, that is the system can work simultaneously.

| Action on Apps Lamp 1 | Action on Apps Lamp 2 | Output Lamp 1 | Output Lamp 2 |
|-----------------------|-----------------------|---------------|---------------|
| ON                    | ON                    | ON            | ON            |
| ON                    | OFF                   | ON            | OFF           |
| OFF                   | ON                    | OFF           | ON            |
| OFF                   | OFF                   | OFF           | OFF           |

In testing the auto mode tool system, it can be seen that the system in manual mode can work based on user input data by controlling and monitoring lights in the manual menu interface on the Android application. In this mode the system plays a role in replacing conventional switches in the house, where with this tool system the user is made easy to control and monitor lights using a smartphone, this can be done in real time and can be controlled remotely because it uses the concept of the Internet of Things.

5. Conclusion

After testing and analysis program of the tool system, it could be concluded as follows. This tool can work to turn on and turn off lights automatically or manually with the Wemos D1 microcontroller control. In automatic mode, this tool works based on input data from two types of devices, namely the LDR sensor and the PIR sensor. Whereas in manual mode this tool works based on input data from the android application which is controlled and monitored by the user.
In this automatic light system, the lights that are controlled on and off are 2 lights. The lights are controlled separately, where in room 1 there is a lamp 1 which uses a PIR sensor while in room 2 there is a lamp 2 which uses a PIR and LDR sensor. Communication between the microcontroller with 2 types of sensors and other components is connected via the respective ports on the microcontroller. The function configuration of each pin on the microcontroller for connecting input and output devices is done through the programmer.

The tools that have been designed in this study have been tested and can work properly but there are still weaknesses and shortcomings. For this reason, further development is needed so that in the future this tool is more perfect.

The suggestions for improving this tool for further development are as follows. Selection of a better performance PIR sensor that can detect human presence at a longer range and has better penetration of obstacles. It is necessary to develop this system so that this system can not only be applied to lights, but can also be applied to household electronic equipment. And additional security features are needed in this tool system.

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