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Design and Construction of Automatic Lighting System Using Microcontroller Based on Wireless Sensor Network

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***Abstract*—A manual system that can be improved with an automatic system, one of which is the lighting system. The use of lights in the community today is considered not in accordance with their use, often the lights are still on even though they are not used, this is a waste. The type of research used is manufacturing or development research, this research aims to design and build an automatic lighting system using a Wireless Sensor Network (WSN)-based microcontroller that has a problem of wasting electricity in the use of lights. Based on this problem, an implementation of a wireless sensor network using a microcontroller was made to reduce waste in using electricity. The way the system works is that the node device system will send the sensor reading data to the gateway every time there is a change in the data. After the data is received, the gateway is then uploaded to the firebase database first and then accessed on the user's application on the smartphone. The test results show that the system made by both hardware and software is running according to plan with the detection latency of camera one is per 0.233 milliseconds, the detection latency of camera two is per 0.213 milliseconds, the detection latency of camera three is per 0.219 milliseconds, but this latency is highly dependent on the strength of the Wi-Fi signal used. This system is able to reduce the use of electricity by 5 watts, and 7.5 rupiah per hour.**

Keywords*— *Android, Automatic Lighting, Energy Efficiency, IoT, Wireless Sensor Network.

I. INTRODUCTION

The development of information and communication technology has had a significant impact on various aspects of human life, including in the field of home and building automation. One of the rapidly developing technologies is the automatic lighting system. The system is designed to reduce the waste of electrical energy. One of them is the waste of electricity because it is not always necessary to turn on all at once. Other electrical appliances with large electricity consumption are rice cookers, lamps, and computers [1]. With an automatic lighting system, the use of electrical energy can reduce the waste of electrical energy because the lamp will turn on only when needed.

With this automated system, it is hoped that it can improve the previous system, namely the manual system which still requires human supervision [2]. Through microcontroller-based automatic switches can be useful to reduce the use of electrical energy. The use of electricity in room lighting needs to be managed properly and correctly, such as campus buildings, warehouses, and offices. In general, turning the lights on and off in the office is done manually, where users often forget or neglect to turn off the room lights after use, or even the lights are left on when no one is there. Therefore, to overcome the above problems, there is proper planning, so the idea is to use a tool that controls electrical equipment so that its use does not waste electricity. Sensors are mobile, meaning that at some point it will be possible to move the sensor to get more precise measurements without having to worry about changing the design of the room or the arrangement of the room cables [3]. This can be done by using PIR motion sensors and CCTV cameras integrated with Wireless Sensor Networks (WSN). CCTV camera is a recording device that uses one or more video cameras and generates video or audio data. CCTV is the use of video cameras that transmit signals or broadcasts aimed at a specific device, namely a set of monitors [4]. Wireless Sensor Network is a combination Of several technologies, these technologies work together effectively complement perception in real-time from data information, monitoring, acquisition, analysis and Transmission [5]. Wireless sensor network (wsn) works with several nodes that do sensing and can regulate the environment, and there is interaction between humans and computers as well as the surrounding environment, WSN nodes are usually small machines and are powered by batteries. Allows sensors placed at various points in the room to communicate wirelessly. The system has a reference if a human presence is detected in the room, then the microcontroller will command the relay to connect the light to the power source. In contrast, if there is no human presence in the room, the microcontroller will send a command to the relay to cut off the electrical current to the

lamp. To program the microcontroller, the software used is the Arduino IDE, Software Processing is a combination of C++ and Java programming languages. Arduino software institutions are also very easy to run on various platforms such as on the LINUX operating system, Mac OS, Windows. Arduino is not just a development tool, but a combination of hardware, programming languages and a sophisticated Integrated Development Environment (IDE) [6]. Therefore, energy-efficient data aggregation techniques that increase network lifespan are significant. Various approaches and algorithms for energy-efficient data aggregation in IoT-WSN systems are presented [7].

II. METHOD

The type of research used is manufacturing or development. Development research is a research method used to produce certain products. The most common development research is one that involves a situation where product development is carried out, then an analysis is carried out [8].

A. Block Diagram

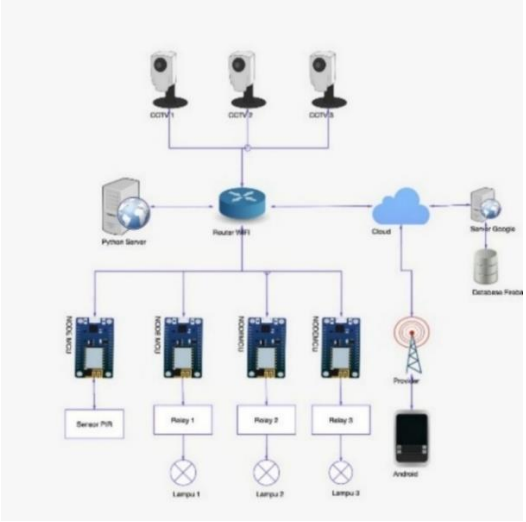

Figure 1. Block diagram

Figure 1 is diagram block on planning system which is done for prepare apps and the database. This process begins with a CCTV camera and PIR sensor that acts as an input, PIR sensors has detection capabilities as far as 20 feet or 6 meters with a detection angle 110° x 70° [9]. Are sensors commonly used to detect the presence of humans. This application is usually used for alarm systems in homes or offices. A PIR sensor is a sensor that captures the infrared signal emitted by the human body as well as animals. PIR sensors can respond to changes in the infrared signals emitted by the human body [10]. A nodeMCU serves as a microcontroller has integrated the ESP8266 into a compact board with various functions similar to those of a microcontroller, along with the capability to access Wi-Fi and a USB to Serial [11]. A Wi-Fi, cloud, and server signal as a transmission medium, as well as an android application as a control medium, and lights as an output.

The CCTV camera capture will be processed by the YOLO algorithm, YOLO is an algorithm developed to detect an object in real-time. The detection system is carried out by using a repurpose classifier or localizer to carry out detection. The system we offer is also capable of checking the position or location of objects using Global Positioning System (GPS) technology. The results of this test show an accuracy of 0.93435, with the lowest still within the range of 93%, while the average accuracy is 93.26% [12]. A model is applied to an image at multiple locations and scales, where the area with the highest score will be considered as a detection [13]. Which will be read by the microcontroller, and will be sent to the Firebase database for real-time data storage and displayed in the Android app. Firebase Database is a non-SQL database storage that allows for storing several types of data. These data types include String, Long, and Boolean. Data in the Firebase database is stored as a JSON tree object. Unlike SQL databases, there are no tables or rows in non-SQL databases. When data is added, it becomes a node in the JSON structure [14]. It will then be passed on to the relay that will turn the lights on or off. This android application itself has an important role, This android application is made using an editor, namely Android Studio, Android Studio is an IDE that can be used for android application development, and is developed by google. Android Studio is a development of the Eclipse IDE, and is based on the popular java IDE, namely Intellij IDEA, Android Studio is planned to replace eclipse as the official for android application development [15]. Namely to monitor and control CCTV cameras and lights remotely. The app can also display every connected CCTV and can manually control each light or make it automatic.

B. Overall Toolset Schema Design

Here is the overall set of tools in the creation of this system.

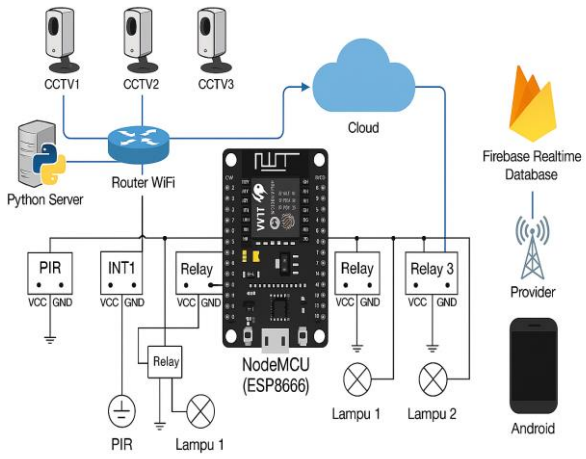

Figure 2. Overall toolset schema design

The following is a more detailed block diagram of the overall system shown in Figure 2. NodeMCU as the main

microcontroller that controls the relay and PIR input, then processed by the Wi-Fi router, which also manages the data from the python server and the input of the three CCTV camera and forwarded to the cloud server, and will be the output of the light. For the user side of the controlling input from the user's smartphone and will be transmitted through the provider signal or Wi-Fi signal, and processed by the real-time firebase database.

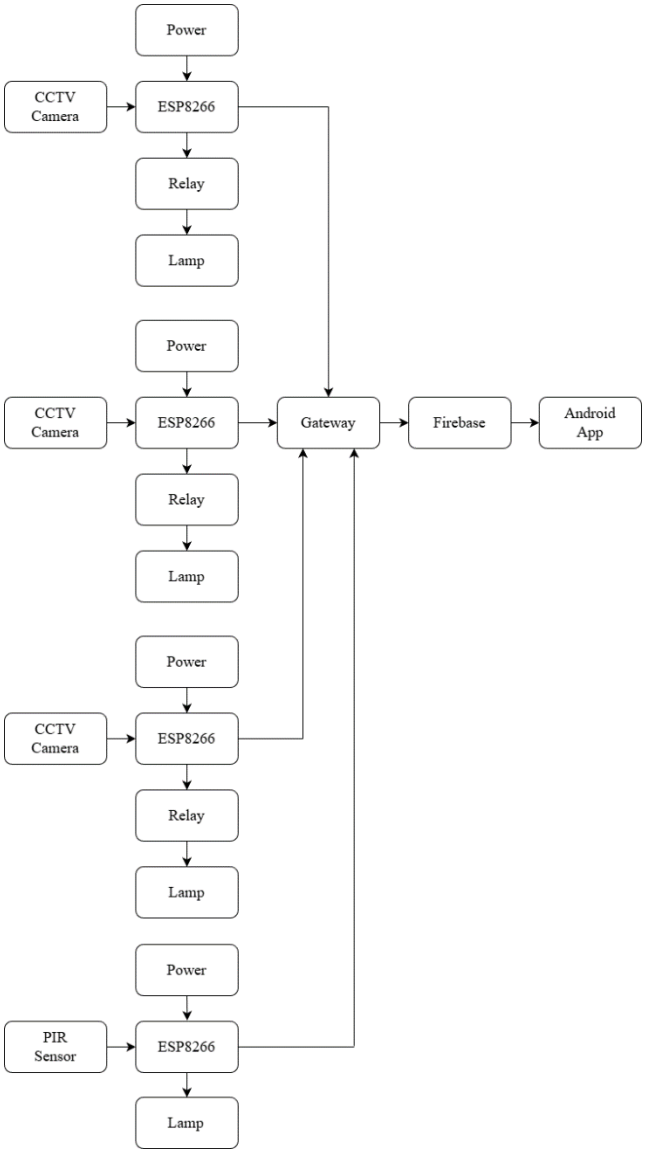

Figure 3. System diagram blocks

It can be seen in the image above is the overall diagram block shown in Figure 3, where the PIR sensor and CCTV camera are the input and then ESP8266 becomes the process stage, and the light becomes the output, then the results of the esp8266 processing are forwarded to the gateway and firebase to be displayed on the user's android application, and there is power from the power outlet for the CCTV camera and processing unit.

C. System Flowchart

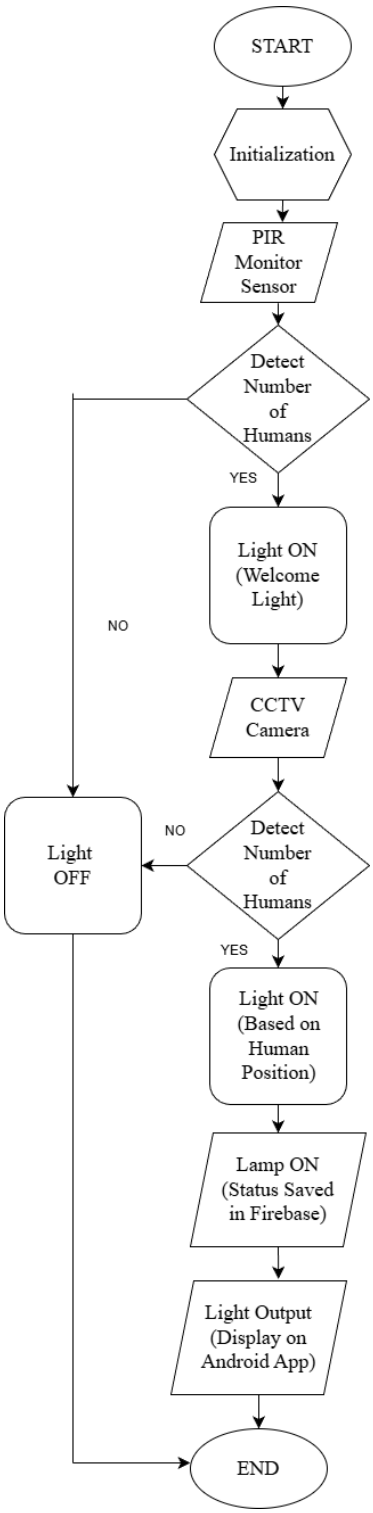

Figure 4. Overall flowchart

Figure 4 explains the flowchart system as a whole. First, the initiation is input from the pear motion sensor when detecting human movement and then will turn on the light as a "Welcome Light", then if the CCTV camera

detects a human being who is within the range of the CCTV camera, the CCTV camera will turn on the light according to which CCTV camera in which room.

D. App Flowchart

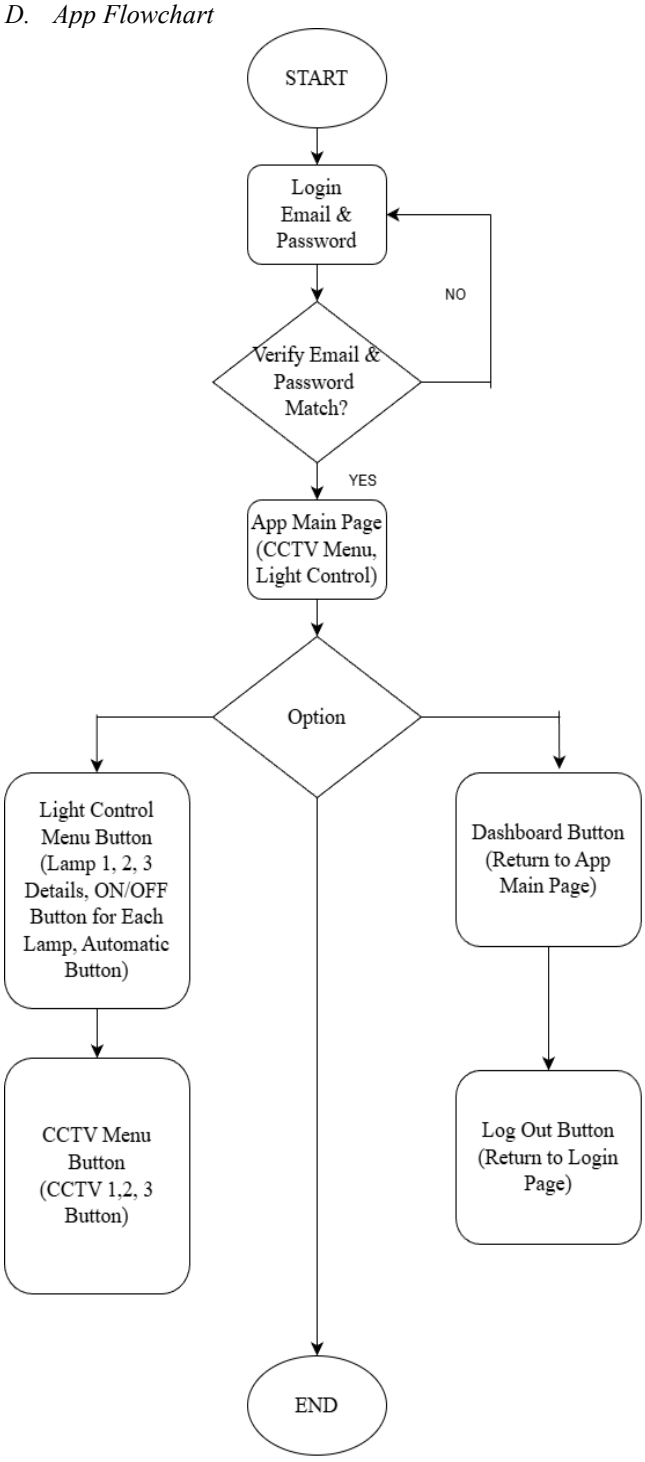

Figure 5. App flowchart

Figure 5 above is a flowchart of the application that users can use to control and monitor by registering their email and password first, then logging in using the verified email in the application.

III. RESULTS AND DISCUSSION

A. Interface Implementation

Figure 6. Login screen

Figure 6 Here is the Log In page or the initial view when the app was first opened.

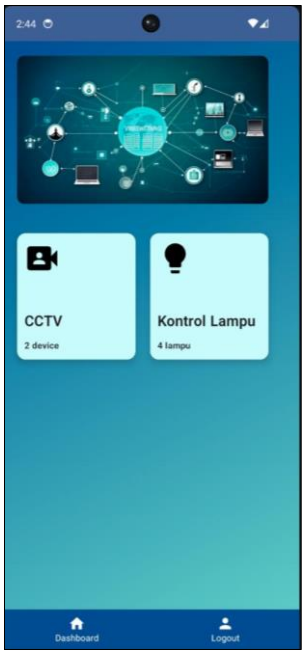

Figure 7. Main screen

Figure 7 of this page is the main page after login, on this page there are four menu buttons, a CCTV menu button to see CCTV in each room, a light control button to remotely control each light from a smartphone, a dashboard button to return to the main page, and a logout button to exit the application and return to the login page.

Figure 8. CCTV page

Figure 8 on this page there are three buttons that have the same function, namely the button of each CCTV in three different rooms, the CCTV button 1 will display the CCTV in room 1, as well as the other two buttons.

Figure 9. Lights control page

Figure 9 on this page there is a light description box at the top which indicates what condition the lights are in, then there are two buttons on each light to turn the lights on and off, and the last button at the bottom is the auto button which changes the light on and off automatically using a CCTV camera.

B. System Test Results

1) Camera Test

Figure 10. Camera test results

Figure 10 is the result of testing the camera at night using an infrared sensor. Figure 10 is the result of the camera test at adequate lighting so that it does not use the CCTV infrared sensor.

Figure 11 and 12 are the results of the App test and the synchronization between the app and the database.

Figure 11. Application test results

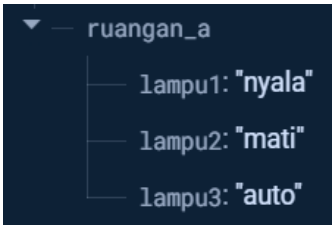

Figure 12. Database synchronization results

From the results of the above application tests, it shows that the data in the application and in the database is synchronous.

2) Latency

Here are the results of the latency test of each CCTV camera.

```
0: 384x640 1 person, 235.0ms
0: 384x640 1 person, 233.0ms
0: 384x640 289.0ms
0: 384x640 260.0ms
0: 384x640 232.0ms
0: 384x640 1 person, 232.0ms
0: 384x640 1 person, 240.0ms
0: 384x640 1 person, 222.0ms
0: 384x640 1 person, 225.0ms
0: 384x640 1 person, 197.0ms
0: 384x640 1 person, 213.0ms
0: 384x640 1 person, 210.0ms
0: 384x640 1 person, 215.0ms
0: 384x640 1 person, 203.0ms
0: 384x640 2 persons, 212.0ms
0: 384x640 229.0ms
0: 384x640 230.2ms
0: 384x640 223.0ms
0: 384x640 220.0ms
0: 384x640 214.0ms
```

Figure 13. CCTV camera latency test results camera CCTV1

It can be seen in figure 13 CCTV 1 has an average latency or refresh delay of 0.233 milliseconds.

```
0: 384x640 1 person, 213.0ms
0: 384x640 1 person, 201.0ms
0: 384x640 1 person, 204.0ms
0: 384x640 1 person, 208.0ms
0: 384x640 1 person, 221.0ms
0: 384x640 1 person, 206.0ms
0: 384x640 1 person, 216.0ms
0: 384x640 1 person, 216.0ms
0: 384x640 1 person, 217.0ms
0: 384x640 1 person, 206.0ms
0: 384x640 204.0ms
0: 384x640 1 person, 210.0ms
0: 384x640 218.0ms
0: 384x640 211.0ms
0: 384x640 200.0ms
0: 384x640 205.0ms
0: 384x640 208.0ms
0: 384x640 211.0ms
0: 384x640 222.0ms
```

Figure 14 CCTV camera latency test results camera CCTV2

Then, Figure 14 CCTV 2 has an average latency or refresh delay of 0.213 milliseconds.

```
0: 384x640 1 person, 213.0ms
0: 384x640 1 person, 201.0ms
0: 384x640 1 person, 204.0ms
0: 384x640 1 person, 208.0ms
0: 384x640 1 person, 221.0ms
0: 384x640 1 person, 206.0ms
0: 384x640 1 person, 216.0ms
0: 384x640 1 person, 216.0ms
0: 384x640 1 person, 217.0ms
0: 384x640 1 person, 206.0ms
0: 384x640 204.0ms
0: 384x640 1 person, 210.0ms
0: 384x640 218.0ms
0: 384x640 211.0ms
0: 384x640 200.0ms
0: 384x640 205.0ms
0: 384x640 208.0ms
0: 384x640 211.0ms
0: 384x640 222.0ms
```

Figure 15. CCTV camera latency test results camera CCTV3

And, Figure 15 CCTV 3 has an average latency or refresh delay of 0.219 milliseconds.

3) Wattmeter test results

Figure 16 Test Results of wattmeter (a) without automatic lighting system (b) with automatic lighting system

Figure 16 (a) Test results of wattmeter without automatic lighting system, the Electrical Power used to turn on three lights at once within an hour is 0.011 kWh, multiplied by the price per 1kWh is Rp 1.500. So, a value of 16.5 rupiah. Figure 16 (b) Test results of wattmeter with automatic lighting system, The Electrical Power used to turn on three lights at once within an hour is 0.006 kWh, multiplied by the price per 1kWh is Rp 1500. So, a value of 9 rupiah.

From the two images above, the automatic lighting system can reduce the cost of using electrical energy by 7.5 rupiah per hour or 5 watts per hour.

IV. CONCLUSION

Based on the results of the research on the automatic lighting system using a microcontroller based on the Wireless Sensor Network, it can be concluded that human detection hardware and microcontrollers made using CCTV cameras and pear motion sensors can be concluded. The control and monitoring application is created using Android Studio and using the Firebase database. With this application, it will make it easier for users to control and monitor the room they want. Based on the results of the wattmeter test, the difference in costs incurred to turn on three lights using an automatic light system and without an automatic light system is 7.5 rupiah per hour or 5 watts per hour.

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