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Automated building lighting control by using R3 Arduino Uno

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ABSTRACT

Lighting is a fundamental need in daily life; however, conventional lighting systems that are still widely used today tend to be inefficient due to manual operation. This often leads to energy waste, especially when lights are left on during the day or in unoccupied rooms. This final project discusses the design and implementation of an automatic lighting system based on a light sensor (LDR) and motion sensor (PIR), aimed at improving energy efficiency in building environments. The system is designed to activate the lights only when two conditions are met simultaneously: the presence of a person in the room and low ambient light intensity, using an AND logic as the decision-making basis. Test results show that the system responds accurately, consistently, and reliably to environmental changes, and is capable of significantly reducing electricity consumption. By adopting this automation technology, the system not only supports energy savings and reduces operational costs but also contributes to environmental preservation through the reduction of carbon footprint.

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1. INTRODUCTION

Lighting is a fundamental need in human life, essential in various environments such as households, offices, and public facilities. Good lighting allows people to see objects clearly and contributes to a pleasant visual atmosphere, improving comfort and productivity [1]. Despite its importance, many existing lighting systems still operate manually, which often leads to inefficient energy usage. For example, lights may remain on during daylight hours or when rooms are unoccupied, resulting in unnecessary electricity consumption and increased operational costs.

The building sector is one of the largest contributors to overall electricity consumption and environmental impact worldwide [2]. Within buildings, lighting systems, cooling units, and electronic equipment such as computers and printers consume the majority of electrical energy [3]. Many office buildings still rely on manual control for lighting without the support of sensors that can adjust lighting intensity automatically based on ambient conditions or occupancy. This lack of automation causes lights to be left on unnecessarily, leading to significant energy wastage [4]. The inefficient usage patterns not only raise operational expenses but also increase the carbon footprint, contributing to broader environmental challenges.

Advancements in technology are pushing society towards greater modernization, where automation plays a crucial role in enhancing efficiency and convenience [5]. Automated lighting systems that use sensors can operate independently by adjusting to environmental factors such as natural light availability and human presence. Numerous studies have developed such smart lighting solutions aimed at energy savings. For instance, Deng [6] created the Smart Automatic Lighting System (SALS) to optimize energy use through microcontroller-based control. Aussat et al. [7] designed a system capable of monitoring the environment and self-calibrating for optimal power use, while Sun et al. [8] developed a classroom lighting system that adjusts brightness, color temperature, and light distribution according to different zones.

Considering the urgent need to reduce energy consumption and the potential benefits of automation, this research proposes designing an automatic lighting control system using Arduino Uno R3. The system integrates a light sensor to detect ambient illumination and a motion sensor to sense room occupancy, allowing lights to turn on automatically when the environment is dark or when movement is detected, and turn off when not needed. This approach not only reduces electricity consumption but also extends lamp lifespan and improves the overall operational efficiency of building lighting systems.

2. METHOD

This study applies the waterfall method, which is a systematic and sequential approach used in the system development process [9]. This method consists of five main stages, starting from user requirements specification, followed by design, implementation, verification, and finally maintenance.

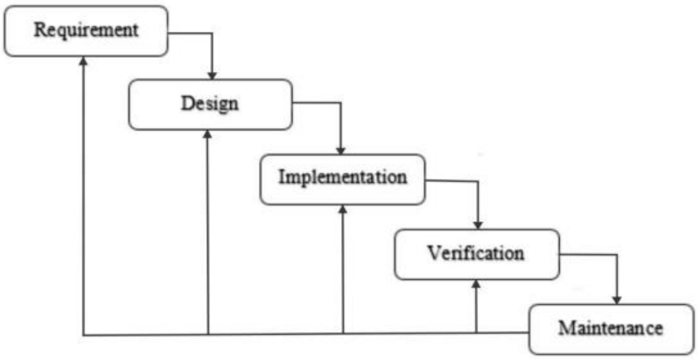


Figure 1. Stages of the waterfall metode

In the requirements stage, the researcher identifies the parameters to be detected by sensors, such as human motion and indoor light intensity. This stage also involves determining the specifications of the necessary sensors and analyzing the requirements for devices and components. Next, during the design stage, the researcher develops the schematic design of the electronic circuit, creates a flowchart for the automatic building lighting system using Arduino Uno R3, and plans the layout of the components.

The implementation stage involves assembling the hardware, programming the ESP32 microcontroller to read sensor data, and integrating all components into the automatic building lighting system based on Arduino Uno R3. Following this, in the verification stage, the researcher conducts sensor calibration tests and ensures the system operates in accordance with the programmed instructions. Finally, the maintenance stage includes regular calibration of the PIR and LDR sensors, cleaning of components, and replacing any worn or damaged parts to ensure the system remains functional and reliable over time. A block diagram is a system representation that displays the main parts or main functions of a system in the form of boxes connected by lines [10].

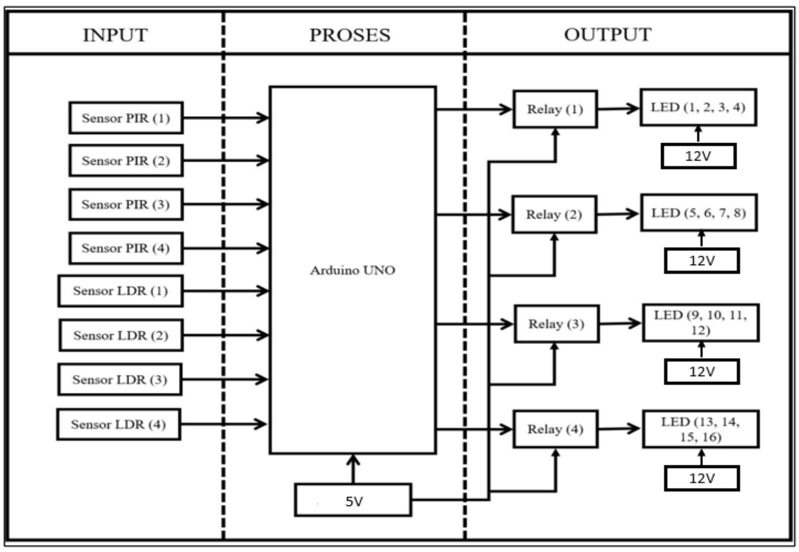


Figure 2. Block Diagram

Block diagrams are used to describe the relationship between parts in a system. Block diagrams allow users to understand how the whole system works. Its main function is as a guide in arranging and connecting components in electronic circuits. The block diagram consists of three main parts: 1) Input Block - The input block consists of four PIR sensors to detect human movement inside the room and four LDR sensors to measure the light intensity within the room. The data collected from these sensors are sent to the Arduino Uno for processing. 2) Processing Block - The data received from the sensors is processed by the Arduino Uno. The outcome of this processing determines the system's output behavior. 3) Output Block - The output block includes relays and lamps, where the relay functions as a switch to control the flow of electricity to the lamps, which act as the system's output components. When the sensors detect that the lights need to be turned on based on the PIR and LDR inputs, the relay activates (closes the contact), allowing electrical current to flow to the lamps.

The circuit scheme ensures that each component is connected to each other so that the system can work according to its respective functions. In depicting the circuit scheme, each component can be depicted in its own form or represented with symbols.

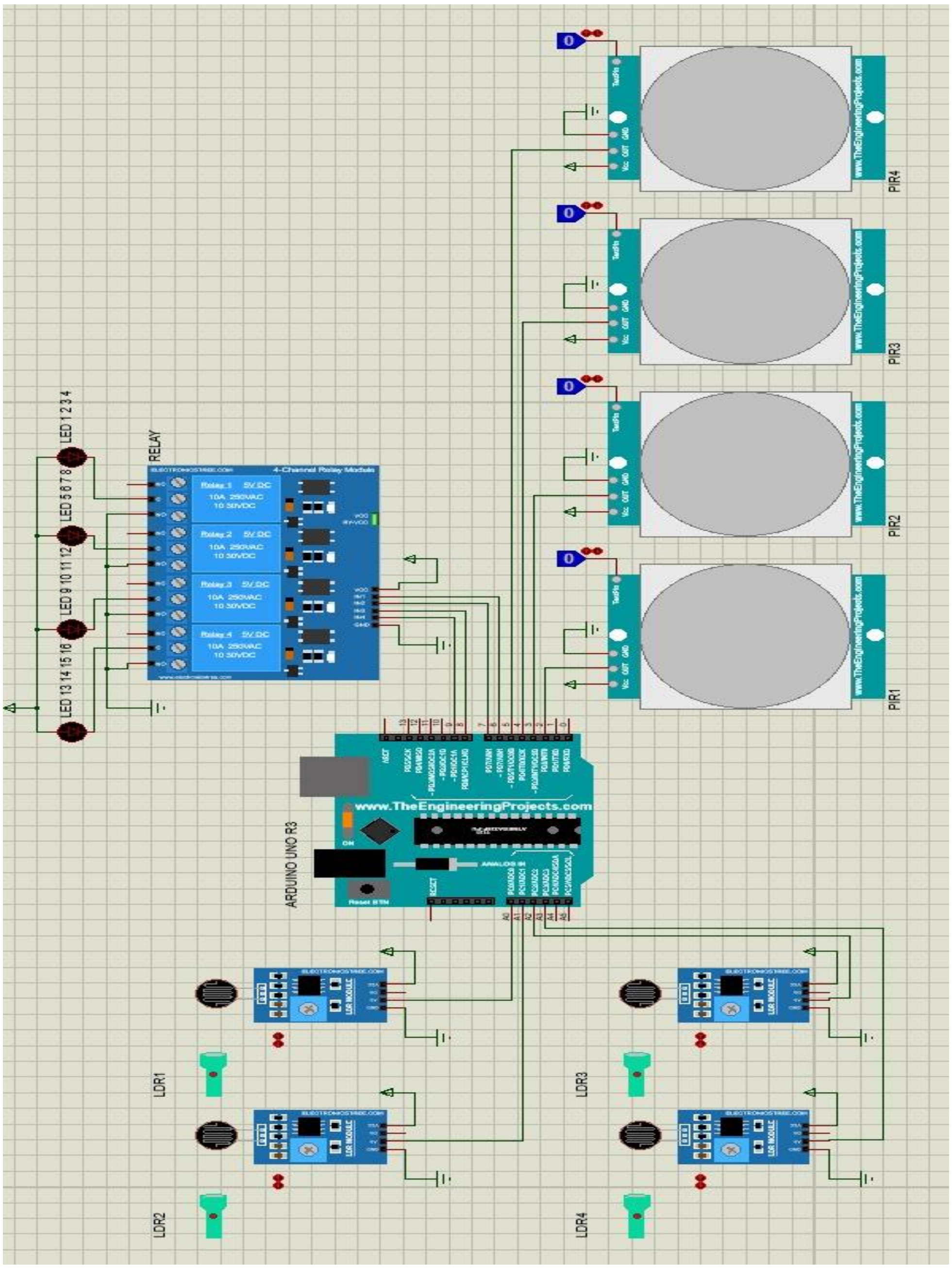


Figure 3. Circuit Schematic

Flowchart is a diagram or chart that describes the flow of processes or steps in a program, including the relationship between processes and statements involved in it [11]. Flowchart consists of several symbols connected by lines, with each symbol having its own meaning. Flowcharts are also used to represent the conceptual structure of complex software systems, serving as design documents used by system analysts to communicate, negotiate and represent the complexity of a process [12].

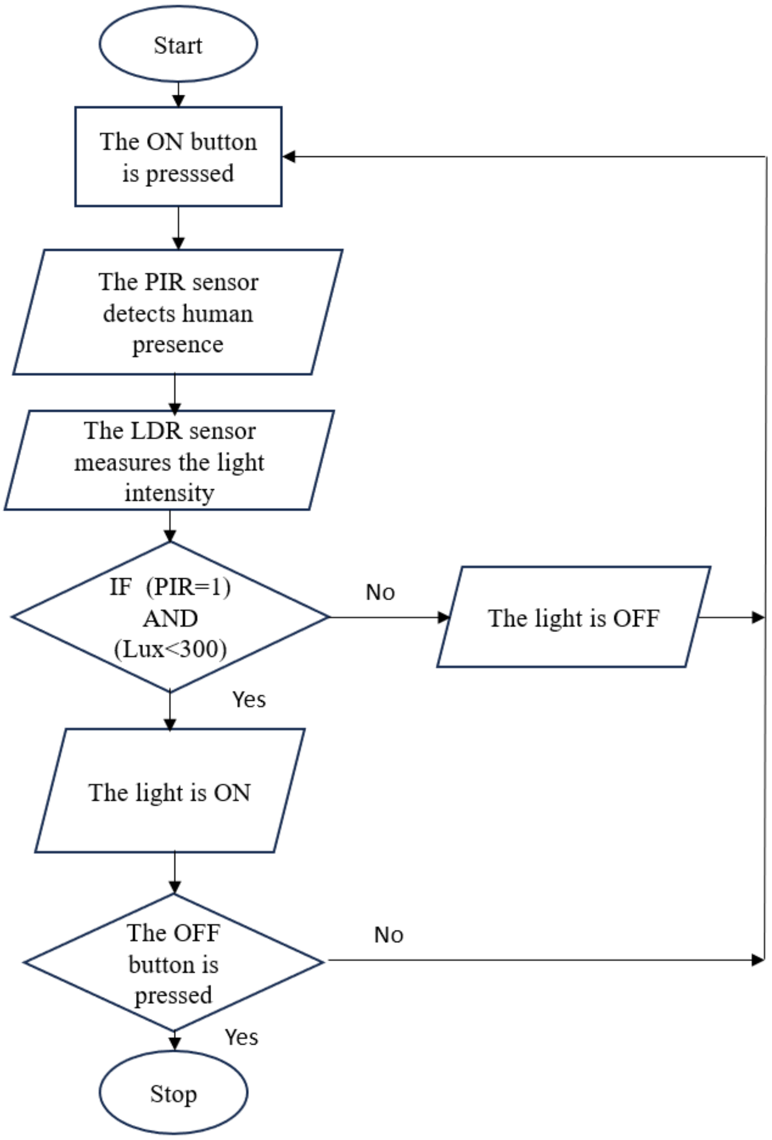
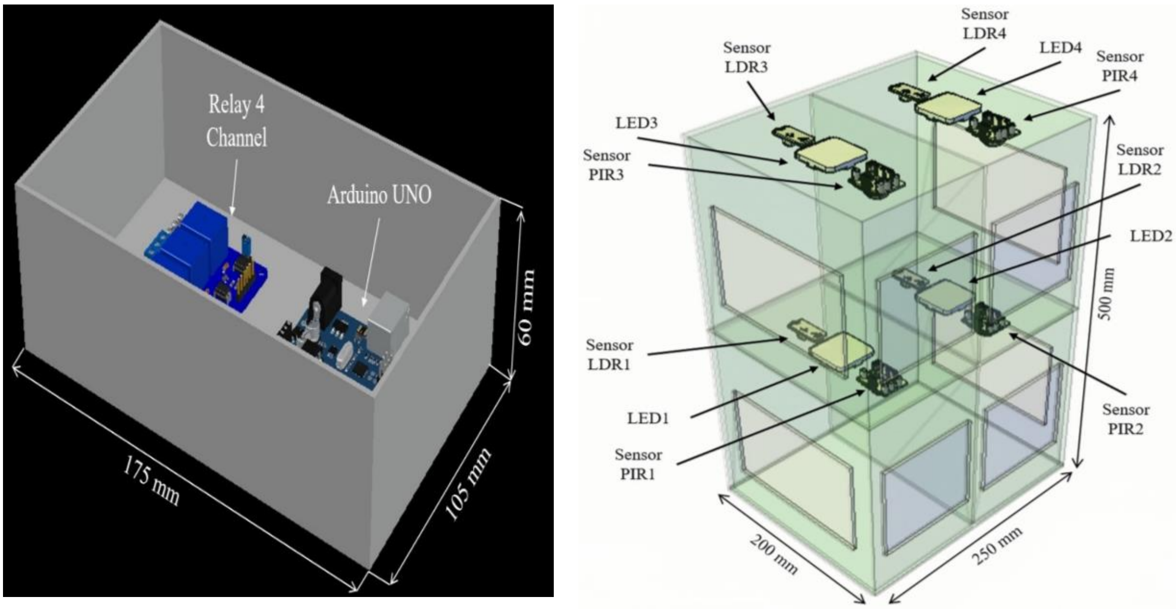


Figure 4. Flowchart

1) The process begins when the system is activated through a switch. Then, the LDR sensor and PIR sensor start working to measure the light intensity and detect movement in the room. The measurement results of these parameters will be processed by the Arduino Uno. 2) If the PIR sensor detects the presence of a person in the room, it is interpreted as logic 1. If the PIR sensor does not detect any presence, it is interpreted as logic 0. 3) The LDR sensor detects the light intensity in the room: dark condition (Lux = 0), dim condition (Lux < 300), and bright condition (Lux ≥ 300). The logic is 1 if the lux level in the room is less than 300, and 0 if it is 300 or higher. The value of 300 lux is used as a reference because the type of building for this final project is an administrative office, which requires a lighting standard of 300–500 lux according to SNI (Indonesian National Standard) [13]. 4) This system uses AND logic, where the output will be 1 only if both inputs are 1. If the AND logic condition is met (PIR = 1 and Lux < 300), the light will turn on. 5) If the AND condition is not met, the light will remain off, and the sensors will continuously re-measure the parameters in a loop. Hardware design is the process of designing, planning and developing the physical form of a system, including architectural design, component selection and technical specifications of the device to be made [14].



(a) (b)

Figure 5. Hardware Design (a) Component box design and (b) Miniature building design

The component box, which houses the Arduino Uno and relay module, is also made of acrylic and has dimensions of 175 mm in length, 105 mm in width, and 60 mm in height. The building miniature consists of two floors, with each floor containing two rooms. The miniature is made of acrylic material, with a building length of 250 mm, a width of 200 mm, and a total height of 500 mm. Software design is a process that involves planning a software system that creates a framework to meet user needs [15].

Figure 6. Software design on Arduino IDE

The system’s programming algorithm was developed and implemented using the Arduino IDE, which is used to write, compile, and upload code to the Arduino Uno microcontroller.

3. RESULTS AND DISCUSSION

The lighting system testing was conducted to ensure that the PIR and LDR sensors could work integrally to automatically control the lamp conditions. The PIR sensor functions to detect the presence of people in the room, while the LDR sensor detects the ambient light intensity. Based on the combination of these two sensors, the system decides whether the lamp should be turned on or remain off. The following table shows the test results from various possible conditions inside the room.

Table 1. Lighting system testing

No.	PIR Sensor	LDR Sensor	Lamp
1	Human presence detected in the room	Sufficient room lighting	Off
2	Human presence detected in the room	Insufficient room lighting	On
3	No human presence in the room	Sufficient room lighting	Off
4	No human presence in the room	Insufficient room lighting	Off

The Table 1 shows the test results of the automatic lighting system using two sensors: a PIR sensor to detect the presence of humans and an LDR sensor to measure the light intensity inside the room. The system is designed so that the light only turns on when both the presence of a person is detected and the room's lighting is insufficient. There are four testing scenarios that combine two main conditions, namely human presence in the room and the room's lighting level. Based on these results, the light will turn on only when the PIR sensor detects a person and the LDR sensor detects inadequate lighting (row 2). In other conditions, either due to no human presence or sufficient lighting, the light remains off, indicating that the system operates efficiently and according to the designed logic.

4. CONCLUSION

After the design, observation, testing, and data collection from each trial conducted on the automatic building lighting system device based on Arduino Uno R3, the following conclusions were drawn from this final project design: 1) The device is capable of automatically turning the lights on and off based on the detection of human presence in the room. 2) The device is capable of automatically turning the lights on and off based on the light intensity in the room.

REFERENCES

[1] G. P. Pratama, Y. Yuningtyastuti, dan T. Sukmadi, "Perancangan Dimer Lampu Secara Otomatis Berbasis Mikrokontroler Pada Penerangan Dalam Ruangan," Transmisi: Jurnal Ilmiah Teknik Elektro, vol. 15, no. 4, hlm. 186-190, 2014.

[2] A. Rofii, M. Sobirin, dan J. Muliadi, "Prediksi Konsumsi Listrik Bangunan Gedung Menggunakan Model LSTM Untuk Efisiensi Energi Dan Mitigasi Lingkungan," dalam Seminar Nasional Konsorsium Untag Se Indonesia, Nov. 2024, hlm. 53-62.

[3] J. Liu, "Research on Dynamic Weak Current Dimming and Energy Saving System of Intelligent Lighting System Based on Automatic Control Theory," *2024 IEEE 4th International Conference on Electronic Technology, Communication and Information (ICETCI)*, Changchun, China, 2024, pp. 604-608, doi: 10.1109/ICETCI61221.2024.10594101.

[4] N. Verma and A. Jain, "Optimized Automatic Lighting Control in a Hotel Building for Energy Efficiency," *2018 International Conference on Power Energy, Environment and Intelligent Control (PEEIC)*, Greater Noida, India, 2018, pp. 168-172, doi: 10.1109/PEEIC.2018.8665417.

[5] X. Bai, J. Li, Y. Lu and J. Wang, "Research on Automatic Lighting Control Equipment of Tunnel Entrance," *2020 International Conference on Computer Network, Electronic and Automation (ICCNEA)*, Xi'an, China, 2020, pp. 373-377, doi: 10.1109/ICCNEA50255.2020.00083.

[6] A. Pachamanov, K. Georgiev, D. Pavlov, M. Dimitrov and A. Kolev, "Energy-Efficient Lighting Control in Road Tunnels," *2025 Tenth Conference on Lighting (Lighting)*, Sozopol, Bulgaria, 2025, pp. 1-3, doi: 10.1109/Lighting64836.2025.11081773.

[7] Y. Aussat, A. Rosmanis, dan S. Keshav, "A power-efficient self-calibrating smart lighting system," *Energy and Buildings*, vol. 259, p. 111874, 2022, doi: 10.1016/j.enbuild.2022.111874.

[8] B. Sun, Q. Zhang, dan S. Cao, "Development and implementation of a self-optimizable smart lighting system based on learning context in classroom," *International Journal of Environmental Research and Public Health*, vol. 17, no. 4, p. 1217, 2020, doi: 10.3390/ijerph17041217.

[9] Risfendra, Yoga Maulana Putra, H. Setyawan, and M. Yuhendri, "Development of Outseal PLC-Based HMI as Learning Training Kits for Programmed Control Systems Subject in Vocational Schools," in *5th Vocational Education International Conference*, 2023, pp. 506–511.

[10] M. I. Esario and M. Yuhendri, "Kendali Kecepatan Motor DC Menggunakan DC Chopper Satu Kuadran Berbasis Kontroller PI.pdf," *JTEV (Jurnal Tek. Elektro dan Vokasional)*, vol. 6, no. 1, pp. 296–305, 2020.

[11] L. A. Latif, R. Maulana, and R. Hidayat, "Monitoring and Controlling Electric Energy Usage Based on the Internet of Things," *Journal of Industrial Automation and Electrical Engineering.*, vol. 01, no. 01, pp. 75–81, 2024.

[12] M. Yuhendri, E. Mirshad, and A. R. Sidiqi, "Real-time Control of Separately Excited DC Motor Based on Fuzzy PI System Using

Arduino," *Przegląd Elektrotechniczny*, vol. 2024, no. 10, pp. 123–127, 2024, doi: 10.15199/48.2024.10.22.

[13] Badan Standardisasi Nasional, *Standar Nasional Indonesia (SNI) 03-6197-2011: Tata cara perancangan sistem pencahayaan alami pada bangunan gedung*, Jakarta: Badan Standardisasi Nasional, 2011.

[14] Yuchen Zhou, John Baras, and Shige Wang, "Hardware Software Co-design for Automotive CPS using Architecture Analysis and Design Language," *arXiv*, Mar. 2016.

[15] G. Mirskihk, "Software design principles and their application in software development life cycle," Int. J. Softw. Eng., vol. 9, no. 2, 2021.