Analysis of Control Algorithm Development for Artificial Intelligence-Based Manipulator Robots in Industrial Environments

Azza Zahra Mahendra, Hamdani

Abstract

This study aims to develop and test the reliability of an automatic lighting control system based on the Service Set Identifier (SSID). The system is designed to provide an innovative solution for managing lighting, particularly at night, by utilizing the NodeMCU ESP8266 microcontroller integrated with an LDR sensor, LED light, and the Blynk application. The system works by reading light intensity using the LDR sensor, processing the data through the microcontroller, and controlling output devices such as LED lights automatically or manually via a Wi-Fi-based application. Tests were conducted on the main components, including Wi-Fi connectivity, the LDR sensor, LED lights, and the control buttons on the application. The test results showed that the system operated optimally according to the designed scenarios. The LED light could be turned on, turned off, or adjusted in brightness automatically based on light intensity or manually through the application. In addition, the Wi-Fi connection proved stable with a quick response to user commands. The conclusion of this study is that the SSID-based automatic lighting control system demonstrates good reliability and can be relied upon as a solution to improve energy efficiency and user convenience. The system also has potential for further development, such as integration with smart home devices or the addition of IoT-based automation features.

Keywords: System Reliability, Automatic Control, Service Set Identifier, NodeMCU ESP8266, LDR Sensor, Blynk Application.

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Introduction

Technological progress has brought significant changes in various aspects of life, including the use of both analog and digital electronic devices. One of the main applications of technological advancements in the household sector is the implementation of automation systems that use sensors to control various electronic devices, aiming to create smart homes. In the smart home concept, automation systems not only increase convenience but also contribute to energy savings [1][2].

One of the technologies used in smart home sensor systems is NodeMCU, a microcontroller equipped with an ESP8266 module. This module enables NodeMCU to operate wirelessly and support Internet of Things (IoT) functionality. Using the Lua programming language, NodeMCU can effectively control various devices since it supports features such as General Purpose Input Output (GPIO), Pulse Width Modulation (PWM), Universal Asynchronous Receiver/Transmitter (UART), and Analog to Digital Converter (ADC) [3][4][5].

In its implementation, NodeMCU can be connected to the Blynk application, allowing users to monitor and control electronic devices via smartphones based on iOS or Android. The Blynk application provides various monitoring features such as buttons, sliders, graphs, and other widgets. These widgets can display data from hardware components like sensors, making Blynk suitable for simple projects such as temperature monitoring or remote on/off lamp control [6][7].

One important application in smart home systems is the automatic lighting control system, which utilizes sensors to turn lights on and off automatically. This system not only helps reduce electricity consumption but also provides convenience, especially when the house is unoccupied but lighting is still desired at night [8][9]. However, recent studies show that although the Blynk application can control light switching using NodeMCU, the system is not yet fully automatic since it does not adjust lighting based on environmental light intensity [10].

Therefore, this study aims to develop and analyze an automation and remote-control lighting system for smart homes based on NodeMCU ESP8266. The developed system aims to optimize light control by considering ambient light intensity variables and utilizing the Service Set Identifier (SSID) to connect devices within a local wireless network. SSID is used to facilitate communication between control devices (such as the NodeMCU microcontroller) and connected sensors or lamps within the Wi-Fi network [11].

This research will analyze the reliability of the SSID-based automatic lighting control system, particularly regarding operation, functional accuracy, and device management convenience. In addition, it will identify challenges and development opportunities to create a more efficient and practical solution for smart home applications.

Literature Review

2.1. **The Use of IoT Technology in Lighting Control Systems**

In general, lighting control in smart homes is implemented using light sensors and wireless technology to enhance energy efficiency and user comfort. The technology involves microcontroller devices such as NodeMCU equipped with a Wi-Fi ESP8266 module, allowing the device to connect to a local network and be remotely controlled [2]. NodeMCU supports integration with control applications such as Blynk, enabling users to monitor and control lighting via mobile devices based on iOS or Android [3].

One of the main advantages of using IoT technology in lighting control is energy efficiency. By utilizing light sensors that can detect ambient light intensity, lamps can be turned off when not needed or adjusted in brightness according to time or environmental conditions. This aligns with studies showing that automation in lighting systems can significantly reduce energy consumption [4].

2.2. **Service Set Identifier (SSID) in Wireless Network Systems**

In smart home systems, wireless communication between devices is crucial. In this context, the Service Set Identifier (SSID) is a method used to identify and connect devices within a local Wi-Fi network. SSID allows devices such as NodeMCU to connect to routers or access points (APs) in the home network, ensuring smooth communication between devices connected in the system [5].

The use of SSID in automatic lighting control systems simplifies the configuration of devices connected within the smart home network. With SSIDs recognized by devices, communication between controllers (such as microcontrollers) and other devices like light sensors or lamps can be conducted more efficiently and stably. Several studies show that SSID is highly effective in improving the reliability of wireless communication within IoT networks [6][7].

2.3. **Reliability of SSID-Based Automatic Lighting Control Systems**

The reliability of SSID-based automatic lighting control systems depends on several factors, including Wi-Fi signal quality, network stability, and the configuration of connected devices. Previous research indicates that IoT device control using SSID achieves a high success rate in inter-device communication, especially in environments with strong and stable Wi-Fi signals [8].

However, issues often arise in network systems with interference or signal disruptions. In such cases, devices like NodeMCU may struggle to maintain stable connections, affecting the reliability and efficiency of automatic lighting control. Some studies also show that SSID interference or improper network configuration can prevent devices from connecting to the network, ultimately leading to control system failures [9].

Research Methodology

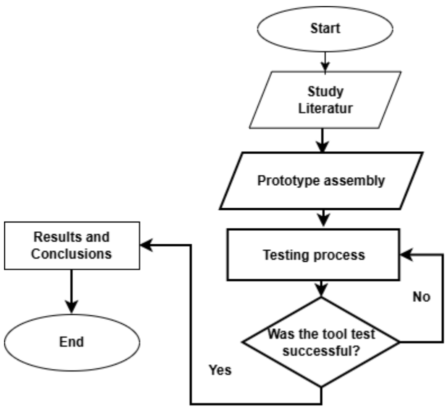

Figure 1. flowchart

Flowchart Description

1. Start: The starting point of the process.
2. Literature Study: Conduct research and review relevant literature to understand the theoretical background or gather necessary information.
3. Create Prototype: Design and develop a prototype based on the literature study and the identified problem.
4. Process: Test or analyze the prototype through experiments or practical applications.
5. Is the Tool Testing Successful?: A decision point.
6. If “Yes,” proceed to Results and Conclusion.
7. If “No,” return to Create Prototype to improve the design or approach.

8. Results and Conclusion: Based on successful testing, analyze the data and summarize the findings.
9. Finish: The process ends here.

This flow illustrates the development and testing process of the device, starting from research to the final conclusion.

Results

In developing the SSID-based automatic lighting control system, precision in design is crucial to ensure that the device operates reliably and efficiently. The design process aims to produce a system that meets both expectations and technical specifications by selecting components most suitable for functional requirements and identifying or minimizing potential errors or technical obstacles. Furthermore, the design also focuses on minimizing costs without compromising the quality and performance of the resulting device.

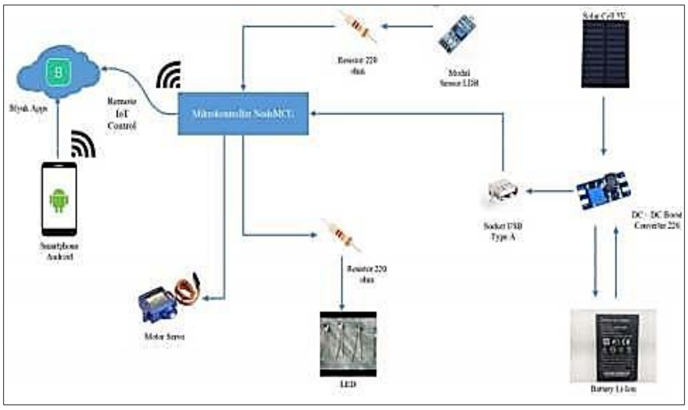

Figure 2. Device Design

4.1. Overall Device Design

The overall design involves integrating various essential elements that form the SSID-based automatic control system. The main elements include the input circuit, control circuit, output circuit, and software. In the input circuit, the LDR (Light Dependent Resistor) sensor is used to read the ambient lighting conditions. This sensor sends data to the microcontroller for further processing.

In the control circuit, the NodeMCU ESP8266 or ESP32 microcontroller functions as the central control unit. It processes data from the sensor and sends commands to the output device. The Wi-Fi module integrated into the microcontroller enables the system to connect to the network via SSID, facilitating remote control. For the output circuit, LED lamps are used as the primary devices that can be turned on or off based on the processed data from the microcontroller. The LED lights can be adjusted automatically based on ambient lighting conditions or manually via remote control.

Additionally, web- or mobile-based software was developed to control the lighting system remotely. The software integrates with the Wi-Fi module through the SSID, allowing users to monitor device status and adjust lighting settings as needed. With a well-integrated hardware and software design, the SSID-based automatic lighting control system is expected to provide high reliability, energy efficiency, and user convenience in operation.

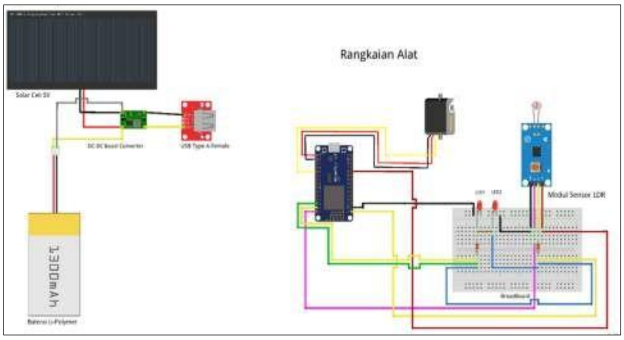

Figure 3. Circuit Schematic

4.2. LDR Sensor Model Design for the Automatic Lighting Control System

The LDR (Light Dependent Resistor) is a resistor component whose resistance value changes according to the light intensity it receives. It functions as a light sensor that depends on ambient illumination. The higher the light intensity, the lower the resistance value, allowing more current to flow. Conversely, under low light conditions (dark), the resistance increases, reducing the current flow.

The LDR sensor detects changes in environmental lighting conditions and generates data used by the microcontroller to control output devices such as LED lights. In the SSID-based automatic control system, the LDR plays an essential role in automating lighting adjustments. The following schematic shows the design of the LDR sensor circuit to support the operation of the system. The circuit is designed to reliably read variations in light intensity and convert resistance values into signals that can be processed by the microcontroller for automatic decision-making.

4.3. LDR Sensor Model Design

The LDR (Light Dependent Resistor) is a sensor component whose resistance changes according to received light intensity. It is used to detect lighting conditions and generate data that can be processed by the microcontroller to control output devices such as LED lamps.

The schematic design of the LDR sensor in this automatic control system is made to work reliably with a NodeMCU-based microcontroller. The following are the connection descriptions:

a. The A0 pin (pink) on the LDR sensor module is connected to the D0 pin (pink) on the NodeMCU.
b. The D0 pin (yellow) on the LDR module is connected to the A0 pin (yellow) on the NodeMCU.
c. The D0 pin (blue) on the LDR module is connected to the positive terminal of LED 1 and LED 2.
d. The VCC pin (red) on the LDR module is connected to the 3V pin (red) on the NodeMCU.
e. The GND pin (black) on the LDR module is connected to the negative terminal of LED 2 (black) on the project board.

This configuration enables the LDR sensor to read light intensity and send signals to the microcontroller, which then controls the lamps automatically depending on light or dark conditions.

4.4. Use of Arduino IDE Software

Designing the system using Arduino IDE is a crucial step in developing microcontroller-based devices. Arduino IDE is used to create, upload, and execute code on microcontroller devices such as NodeMCU ESP8266. The primary goal is to upload the program into the NodeMCU so that it operates according to the intended system design.

In this design, the esp8266 library is used to support NodeMCU control. Once the NodeMCU is connected via a micro USB cable, the next step is selecting the correct port so the device can be detected by the computer and ready for use.

Steps for initializing the program using Arduino IDE:

a. Download and install the esp8266 library in Arduino IDE.
b. Select the board type (NodeMCU ESP8266) via "Tools > Board."
c. Choose the communication port corresponding to the NodeMCU connection via "Tools > Port."
d. Write or import the program designed for the automatic control system.
e. Upload the program to the NodeMCU by clicking the "Upload" button.

This process ensures that the NodeMCU ESP8266 functions according to specifications and supports optimal system operation. Initialization is illustrated through the Arduino IDE interface shown below.

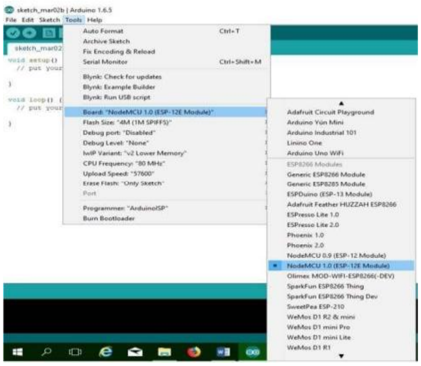

Figure 4. NodeMCU ESP8266 Library Installation

By using Arduino IDE, the development and uploading of programs become more efficient, enabling seamless integration between hardware and software.

4.5. Button Design in the Blynk Application

The design of buttons in the Blynk application is a vital component of this system, as these buttons are used to control lighting automatically through a user interface. The buttons are configured with specific functions based on designated pins, making it easy for users to control and monitor the lighting system.

Below are the buttons included in the Blynk application along with their functions:

Pin	Function
A0	Reads light intensity values from the LDR sensor, determining real-time lighting conditions.
D2	Controls LED brightness, adjusting the light level, especially during nighttime.

D1	Reads LDR sensor status (High/Low) to determine whether the lamp should be automatically turned on or off.
V2	Moves the servo to position 0° (Closed), which can be used to close certain devices in the system.
V3	Moves the servo to position 90° (Open), allowing the device to open as needed.
V1	Moves the servo across multiple angle positions (0°–180°), providing full flexibility in device operation.

By using these buttons in the Blynk application, users can easily control, monitor, and adjust the lighting system directly via mobile devices. This design enhances system efficiency and improves user convenience in managing lighting.

Figure **5.** Buttons and Monitoring on Blynk

4.6. Component Testing

Component testing was carried out to ensure that each element of the system operates according to the design and specifications. This process included preliminary testing of individual components used in the device design and overall system testing after all components were assembled. The goal was to confirm that the system performs optimally. The tests conducted are described below:

4.7. Wi-Fi Connectivity Test

This test aimed to ensure that Wi-Fi connectivity between the NodeMCU microcontroller and the smartphone functioned properly. The testing steps included:

a. Connecting the authentication code from the Blynk application to the device.
b. Entering the Wi-Fi SSID and password into the application.
c. Verifying that the device successfully connects to the Wi-Fi network without issues.

The test results show whether the Wi-Fi connection successfully linked and functioned as a communication bridge between the application and the device. This is essential to support the SSID-based automatic lighting control system.

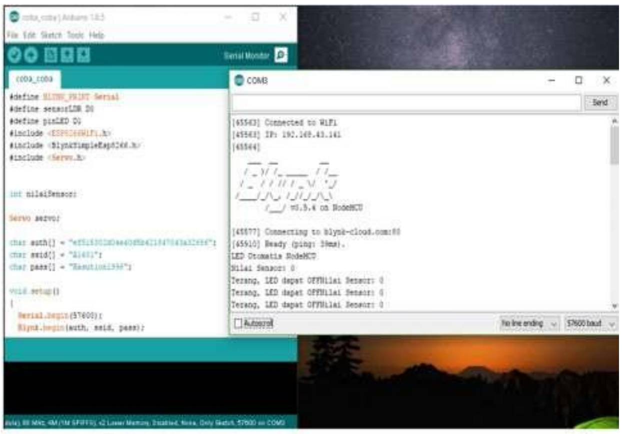

Figure 6. Connectivity Testing via Serial Monitor

4.8. LED Light Testing

The LED light in this system functions as a lighting source during nighttime and can have its brightness adjusted as needed. Its main function is to automatically turn on during the night and turn off when it is bright. Testing was conducted to ensure that the LED could be properly controlled through the application as designed. During the test, the LED could be turned on or off using the slider button in the Blynk application. The "Light Control LED" slider button allowed for brightness adjustment:

a. Sliding to the right turned the lamp on at full brightness.
b. Sliding to the left dimmed or turned off the LED light.

The test results showed that the LED functioned as expected, with responsive control over brightness according to user input through the application. The image below demonstrates the LED's performance under different lighting settings. This test confirmed that the SSID-based automatic lighting control system functioned effectively, ensuring both energy efficiency and user comfort.

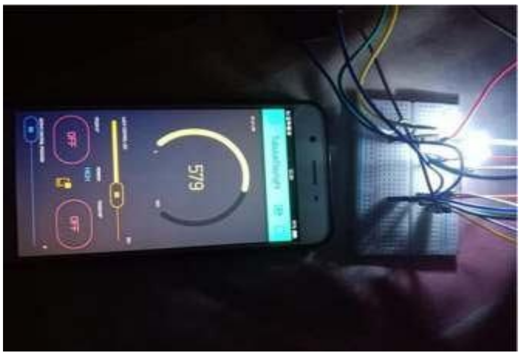

Figure 7. LED Testing

Table 1. Testing of SSID-Based Automatic Lighting Control System

No.	Component Tested	Testing Parameter	Testing Method	Test Result	Conclusion
1	Wi-Fi Connectivity	Connection between NodeMCU and Blynk app	Connecting NodeMCU to Wi-Fi by entering SSID, password,	NodeMCU successfully connected to the application	Connection worked well

			and authentication code		
2	LDR Sensor	Light intensity reading	Comparing LDR resistance values under bright and dark conditions	Resistance decreased in bright conditions and increased in dark	Sensor functioned as designed
3	LED Lamp	Automatic lighting control	Using the Blynk slider to turn on, dim, and turn off the LED light	LED operated according to control settings	LED worked properly
4	Power Supply	Power stability	Measuring DC-DC boost converter output voltage with a multimeter during operation	Output voltage remained stable at 5V	Power supply stable
5	Blynk Application	Button and control response	Monitoring connectivity and the function of buttons such as LED slider and servo controls	Button response was fast and accurate	Application functioned optimally
6	Automatic Control System	Automatic lighting activation based on LDR condition	Monitoring LED light changes when LDR sensor detected dark (night) or bright (day) conditions	LED turned on automatically at night and off during the day	Automatic system worked properly

Testing of the SSID-based automatic lighting control system was conducted to ensure that all components operated according to the designed specifications. The results demonstrated that the Wi-Fi connectivity on the NodeMCU functioned correctly, with the device successfully connecting to the Blynk application using the configured SSID, password, and authentication code. During LDR sensor testing, the sensor accurately detected light intensity resistance values decreased in bright conditions and increased in dark conditions. In addition, the LED light, which served as the lighting output, responded correctly to brightness adjustments, turning on, dimming, and turning off as instructed via the Blynk application. Overall, the testing results confirmed that the system operated optimally and met the expected design specifications, demonstrating reliable performance and efficient functionality.

Conclusion

Based on the results of this study, the SSID-based automatic lighting control system has been successfully designed, implemented, and tested. The system effectively integrates various components such as the NodeMCU, LDR sensor, and LED lights to create a lighting system that can be controlled automatically or manually via the Blynk application. Test results show that the Wi-Fi connectivity is stable, the LDR sensor accurately detects changes in light intensity, and the LED light adjusts its brightness according to user commands. Therefore, the system is considered reliable and capable of improving both energy efficiency and user convenience in lighting control.

This automatic control system offers flexibility through the use of the Blynk-based application, allowing users to easily monitor and control devices remotely. The buttons within the application including those for LED brightness adjustment and servo movement function according to the design and user requirements.

From the testing perspective, all components such as Wi-Fi connectivity, the LDR sensor, LED lights, and control buttons within the application demonstrated optimal performance. The system successfully executed its functions according to the planned scenarios, both in automatic and manual modes.

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