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IOT BASED STREET LIGHT AUTOMATION SYSTEM

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ABSTRACT

Energy conservation and efficient resource utilization have become critical challenges in today's rapidly urbanizing world. Street lighting systems consume a significant portion of a city's electrical energy, and in many cases, lights remain on even when not required, leading to unnecessary wastage. The **IoT-Based Street Light Automation System** provides an intelligent solution by automatically controlling the operation of street lights based on environmental and motion parameters. Using light-dependent resistors (LDRs) and motion sensors (PIR), the system detects ambient light and the movement of vehicles or pedestrians to determine when lights should be turned on or off. The IoT integration enables remote monitoring and control of the lighting network through cloud platforms.

This system helps municipalities reduce electricity consumption, minimize maintenance costs, and promote sustainable urban development. With real-time data logging and analytics, administrators can monitor energy usage and detect faulty lights. The project demonstrates a practical, scalable, and eco-friendly approach to smart city infrastructure.

Keywords: IoT, Smart Street Light, Automation, Energy Efficiency, LDR Sensor, PIR Sensor, Microcontroller, Cloud Monitoring, Smart City, Power Saving, Remote Control.

I. INTRODUCTION

In modern cities, street lighting plays a crucial role in ensuring public safety and visibility at night. However, traditional street light systems often operate on fixed timers or manual switches, leading to significant energy wastage when lights remain on during daylight or low-traffic hours. As cities move toward smart infrastructure, integrating automation into public utilities has become essential. The **IoT-based Street Light Automation System** introduces intelligence and connectivity to conventional lighting systems, ensuring that street lights operate only when necessary.

This system employs **Light Dependent Resistors (LDRs)** to detect ambient light levels and **Passive Infrared (PIR)** sensors to sense motion on the streets. The microcontroller processes data from these sensors and controls the street lights accordingly. For instance, lights turn on automatically at dusk or when motion is detected and turn off when ambient light is sufficient or when no movement is present. The IoT integration allows remote supervision of the entire street lighting network, enabling administrators to identify failures, track energy usage, and optimize performance.

By minimizing energy waste and maintenance efforts, the proposed system enhances urban sustainability and supports the vision of smart cities. It not only reduces operational costs but also contributes to environmental protection through intelligent power management.

II. LITERATURE SURVEY

1. Dr. R. Nair – "Smart Street Lighting System Using IoT"

Dr. Nair proposed a smart lighting system that adjusts illumination based on environmental brightness and human presence. The system used LDR and PIR sensors interfaced with a microcontroller and demonstrated substantial energy savings. The author emphasized how IoT integration allows centralized control of multiple street lights through a web interface. The study concluded that such automation not only reduces energy consumption but also increases the lifespan of lighting equipment through optimized usage. Furthermore, the IoT connectivity supports remote maintenance and fault detection, making it ideal for large-scale deployment.

2. P. Kumar – "Intelligent Energy Management for Street Lighting"

P. Kumar's research focused on optimizing street light energy consumption using sensor-based control systems. The proposed method dynamically adjusted lighting intensity based on traffic flow and environmental conditions. The author also explored the implementation of dimming circuits for partial illumination during low activity periods.

This approach demonstrated a reduction in energy use by nearly 40% compared to conventional systems. The integration of IoT further enabled continuous monitoring, fault reporting, and scheduling, which proved valuable for municipal operations.

3. S. Sharma – "IoT-Driven Smart Lighting for Urban Infrastructure"

S. Sharma's paper introduced an IoT-based model that allowed smart control and remote supervision of urban lighting systems. The model incorporated sensors and wireless communication to transmit real-time data to a central server.

The study highlighted how IoT enables the development of adaptive systems that respond to real-time conditions such as traffic density, weather, and pedestrian movement. The proposed model improved system responsiveness and reliability, making it a strong foundation for smart city applications.

4. V. Mehta – "Automatic Street Light Control Using Sensors"

V. Mehta developed an automatic lighting system that switches street lights based on ambient light levels. The use of LDR sensors allowed automatic transition between day and night operation.

The author emphasized simplicity and cost-effectiveness while maintaining system reliability. However, the absence of IoT capabilities limited the system's remote management potential. This research paved the way for integrating connectivity features to enhance system intelligence and scalability.

5. A. Das – "Energy-Efficient Smart Lighting Using Cloud Connectivity"

A. Das proposed an IoT-based cloud-controlled street light system using NodeMCU and sensors. The system provided real-time status updates of each lamp post and supported remote control through a web dashboard.

The author demonstrated that IoT-based systems can significantly reduce power wastage while allowing maintenance teams to quickly identify malfunctioning lights. The study concluded that cloud integration is key for achieving long-term sustainability and efficient energy management in smart cities.

III. EXISTING SYSTEM

The traditional street lighting systems operate on manual or timer-based controls. In these setups, all lights turn on at a fixed time in the evening and remain on until morning, regardless of environmental or traffic conditions. This leads to massive power wastage and increased operational costs. Maintenance requires manual checking, and faults often go unnoticed for long periods.

IV. PROPOSED SYSTEM

The proposed **IoT-based Street Light Automation System** eliminates inefficiencies by enabling automatic, sensor-based operation. The system uses **LDR sensors** to detect ambient light intensity and **PIR sensors** to detect motion from vehicles or pedestrians. A **NodeMCU microcontroller** processes this data and switches the street lights accordingly. During the night, if no motion is detected, the lights operate in dim mode to save power, and when motion is detected, they brighten automatically.

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Through **IoT integration**, data is sent to a cloud platform like **ThingSpeak or Blynk**, where authorities can monitor system performance, energy usage, and malfunctioning lights in real-time. This results in intelligent illumination control, reducing electricity consumption and maintenance effort while improving operational transparency.

V. SYSTEM ARCHITECTURE

The **System Architecture** of the IoT-based Street Light Automation System consists of the following components:

- **Sensors:** LDR and PIR sensors for light and motion detection.
- **Controller:** NodeMCU (ESP8266) for processing sensor data and controlling lights.
- **Actuators:** LED street lights connected via relay modules.
- **Communication:** Wi-Fi module for IoT connectivity.
- **Cloud Platform:** ThingSpeak/Blynk for remote data monitoring and control.

The sensors feed real-time data to the microcontroller. Based on sensor input and programmed logic, the controller determines when to switch the lights ON/OFF or dim them. The system continuously uploads operational data to the cloud, allowing remote supervision through a web or mobile dashboard.

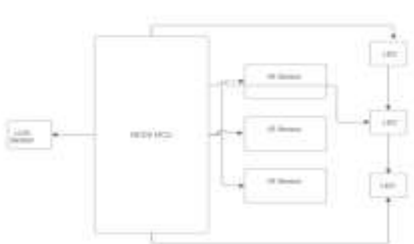

Fig.5.1: Block diagram of proposed model

NODE MCU:

NodeMCU is a low-cost open source IoT platform. It initially included firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which was based on the ESP-12 module.[6][7] Later, support for the ESP32 32-bit MCU was added

OVERVIEW:

NodeMCU is an open source firmware for which open source prototyping board designs are available. The name "NodeMCU" combines "node" and "MCU" (micro-controller unit).[8]. The term "NodeMCU" strictly speaking refers to the firmware rather than the associated development kits.[citation needed]

Both the firmware and prototyping board designs are open source.

The firmware uses the Lua scripting language. The firmware is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson[10] and SPIFFS.[11] Due to resource constraints, users need to select the modules relevant for their project and build a firmware tailored to their needs. Support for the 32-bit ESP32 has also been implemented.

The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controller with a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially was based on the ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with a Tensilica Xtensa LX106 core, widely used in IoT applications

VI. IMPLEMENTATION

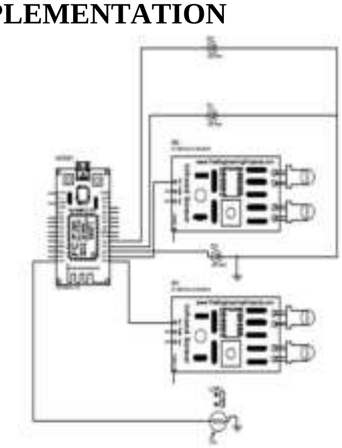

Fig. 6.1: Implementation of proposed model

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In the implementation phase, in fig. 6.1 **NodeMCU microcontroller** is programmed using the Arduino IDE. The LDR sensor is connected to measure ambient light, while the PIR sensor detects movement. The relay driver circuit controls the LED street lights. The NodeMCU connects to Wi-Fi and transmits sensor readings and light status to the IoT dashboard in real time.

When light intensity falls below a set threshold, the system automatically turns on the lights. If no movement is detected, lights remain dimmed to conserve power; they switch to full brightness when motion is detected. The IoT interface allows monitoring of all lights, including their status, energy usage, and fault alerts. This ensures autonomous and efficient lighting management suitable for large-scale deployment.

VII. CONCLUSION

The **IoT-Based Street Light Automation System** effectively addresses energy wastage and maintenance challenges associated with traditional street lighting. By integrating IoT and sensor technologies, the system ensures intelligent illumination that adapts to environmental conditions and street activity. The automation reduces operational costs, improves public safety, and supports sustainable city development. The system's scalability makes it suitable for urban and rural implementation, paving the way for smarter and greener infrastructure.

VIII. FUTURE SCOPE

In the future, the system can be enhanced with **AI-based predictive lighting**, where machine learning algorithms analyze traffic patterns and weather data to optimize brightness levels dynamically. Integration of **solar-powered lights** and **battery storage systems** can make the setup more energy-independent and eco-friendly. Furthermore, using **LoRaWAN or 5G communication** will enable large-scale deployment across cities. The inclusion of **fault prediction algorithms** and **mobile app alerts** can further improve maintenance efficiency. With these enhancements, the system can evolve into a fully autonomous, self-sustaining **smart street lighting network** contributing to the vision of sustainable smart cities.

IX. REFERENCES

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