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An Automatic Streetlight System for Energy Saving

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Abstract: This paper presents as an implementing of a smart streetlight system has become an important feature of modern urban design, especially for improving traffic safety and lowering energy usage. The purpose of this work is to introduce a smart streetlight system that uses PIR and LDR sensors to detect vehicle and pedestrian activity and adjust the brightness of the streetlights accordingly. The system is controlled by the WeMos D1 R32 microcontroller, which enables real-time monitoring of the streetlights and effective energy management. In addition to these functions, the smart streetlight system has an innovative alerting system based on Telegram. The technology is meant to automatically send a notification to maintenance support in the event of a damaged lamp, allowing them to take rapid action to fix the broken lamp. This not only improves the general administration of the streetlight system, but it also assures the safety of citizens by providing appropriate lighting on the streets. The findings show that the smart streetlight system may greatly reduce energy usage by shutting off the lighting when no motion is detected. Overall, the system is a dependable and cost-effective solution that can improve urban road safety and sustainability.

Keywords: Passive Infrared Sensor, PIR, Light Dependent Resistor, LDR, Internet of Things, Telegram

1. Introduction

The Internet of Things (IoT) is the availability of various programming and equipment that exists in the gadget, as well as the device's availability [1]. LED lace lighting frames are currently used to reduce electricity consumption [2]. LED also has the advantage of being easy to control in terms of performance. Inefficient lighting wastes valuable resources, and improper lighting creates dangerous conditions. The harsh mechanism of energy construction technology and demand significantly reduces the price of streetlights [2]. To create energy-efficient and intelligent street lighting systems, as well as rapid maintenance systems that do not rely on residential damage notifications.

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This research implies the addition of new sensor integration, control, and communication capabilities to the existing street lighting system. Due to the primary goal of smart cities being the efficient use of energy, streetlights are managed by automatically turning them on when there are vehicles or pedestrians crossing the street at night [3]. The previous work made use of passive infrared (PIR) and light-emitting diode (LED) sensors. While PIR sensors are used to detect moving traffic or pedestrians, LDR sensors are used to measure light intensity. This streetlight system is being replaced with LEDs to save energy. The WeMos D1 R32 microcontroller connects the PIR sensor module to the network to detect motion.

2. Materials and Methods

This section covered the approach and procedure that were recommended for use in determining whether the intensity of lamps is turned off when it is dark and turn on when vehicles and pedestrians are utilizing the street or crossing it at night. The success of the connection for broken lamps, which will send the notification through Telegram for prompt action by the maintenance assistance, is key to this system.

2.1 Materials

All devices have a specific measuring purpose, however, to support a streetlight, devices are required as a platform to track the streetlight's light output. Additional details on the functionality of the equipment included in this study are shown in Table 1.

Table 1: The function for every component in input, process and output system

Item	Components	Function
Input	PIR sensor	To observe the movement of passing cars and pedestrians. [4]
	LDR sensor	To assess the level of ambient natural light. [5]
Process	WeMos D1 R32 Microcontroller	Serving as a controller to ensure appropriate system operation.
Output	LED streetlight	As a light-producing output.
	Arduino IDE	Programming software for the WeMos D1 R32 microcontroller.
	Telegram	To be notified of the broken lamp.

2.2 Methods

Related sensors are used as input in this work to control the output of the streetlight. WeMos D1 R32 is a piece of embedded hardware. As a result, it is used as a tool for implementing multiple design concepts with a single device, as well as compatibility with both new and existing sensors. The WeMos D1 R32 was used in this work as a microcontroller that will receive program commands from the Arduino IDE. This program will be uploaded into the Arduino IDE software and will cause the LED to light up based on the program's conditions. In this work, the device will monitor the light intensity and movement of the vehicle and notify the user of a broken streetlight via Telegram [5].

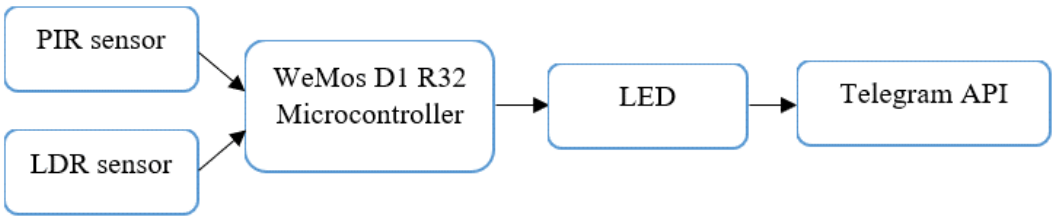

Figure 1: Block diagram for the proposed system

The PIR and LDR sensors are connected to a WeMos D1 R32 microcontroller, which receives commands from an Arduino IDE program [4]. The program causes an LED to light up based on specific conditions. The LDR sensor is used to detect faulty lamps and is connected to each LED, sending data to a WeMos D1 R32 for storage in a Telegram IoT platform. This platform sends notifications to a mobile phone if the lamp fails or is damaged.

3. Results and Discussion

This work produced an IoT-based system for smart streetlights that effectively uses multiple components to offer efficient and effective lighting while lowering energy usage. The components, which include the PIR and LDR sensors, are linked to a WeMos D1 R32 microcontroller board, which serves as the system's brain, adjusting the brightness of the LED lights based on ambient light conditions measured by the LDR sensor and motion detected by the PIR sensor. One of the primary goals of this work is for the system to notify the maintenance staff when a streetlight is damaged or needs repair. This is accomplished by using the Telegram programmed, which sends a notification to the maintenance staff when the system detects that a streetlight LED is turned off, signaling a potential problem.

3.1 Results

The sensor used in this project is a PIR sensor [6], which detects the presence or movement of people or objects passing through the streetlight. During night, the streetlight will turn on if motion detected passing the roads shown in Figure 2.

Figure 2: Streetlight is turned on when motion detected

In terms of IoT use, it works successfully by sending notifications to the Telegram application, which is widely used today because it is simple and accessible wherever we have internet access. Because not all places are passed by vehicles and people at night, this system is also successful in saving energy in the use of streetlights. Figure 3 proves that the system is successfully working during the broken lamp.

Figure 3: The broken lamp notification received via Telegram app

3.2 Power Consumption

A power consumption test was performed comparing the existing system and new system using LED powers of 30W and 10W. Data was collected for four hours and the number of motions passing through the streetlight was recorded. Figure 4 depicts the differences between two systems, with the existing system consuming more power over four hours to continuously illuminate the road. While the new system consumes less power because it only lights up when motion is detected and always turns off if no motion is detected [6].

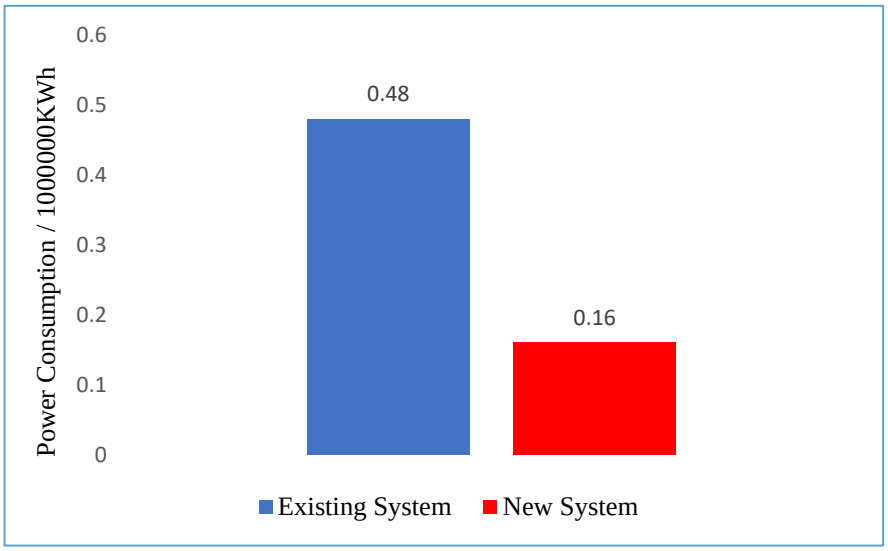

Figure 4: The differences of power consumption between two system

3.3 Discussion

Smart streetlight systems are a new and innovative approach to street lighting that employs sensors and automation to provide a more efficient and cost-effective method of lighting the streets. This system uses motion detection to turn on and off streetlights, which can save energy and reduce the city's overall carbon footprint. Cities that use this system can save a significant amount of money on their electricity bills while also reducing the amount of light pollution produced by traditional streetlights. The system can also help to improve street safety because the lights will turn on automatically when someone walks or drives by.

One of the main advantages of this system is that it can notify the city council when a streetlight is broken or needs to be repaired. This can be accomplished using a notification system, such as Telegram, which can alert the city council to the problem and allow them to act quickly. The system can also help to improve the management of the city's streetlights by providing data on how much energy is being used and when the lights are turned on and off. This data can be used to optimize the system and ensure that it operates as efficiently as possible.

Overall, a smart streetlight system is an excellent investment for any city looking to improve the safety and efficiency of its street lighting. With the ability to detect motion, notify the city council of issues, and provide valuable data on energy usage, this system can help to save money and improve the overall quality of life for city residents.

4. Conclusion

The automatic streetlight system benefits not only the city's finances and infrastructure, but also the environment and citizens' safety. The system can reduce light pollution and provide appropriate lighting for pedestrians and drivers by using motion detection, improving street safety. The ability to monitor energy consumption and control lighting in real time can also contribute to the city's carbon footprint reduction and sustainability efforts.

Finally, installing a smart streetlight system is a cost-effective and innovative approach to street lighting. The system can provide significant benefits to municipalities by saving money, reducing energy consumption, improving safety, and alerting operators to any failures. Furthermore, the use of Telegram as a notification method highlights the system's potential in IoT applications, as well as its ability to improve overall system performance.

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