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IOT based Automatic Street Light Control and Fault Detection

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Abstract -The Internet of Things (IoT) is an emerging technology focused on the interconnection of devices and users, aligning with the growing global demand for smart solutions. In a rapidly advancing tech market like India, this project introduces a smart streetlight framework that enables automatic control and fault detection. The system uses an LDR (Light Dependent Resistor) to switch the streetlights ON or OFF based on ambient sunlight intensity, thereby conserving energy. A relay module regulates power delivery to the lights. Additionally, the system incorporates fault detection by monitoring streetlight status and sends real-time alert messages to an authorized mobile number via the GSM module in case of any malfunction. Motion detection is achieved using an infrared (IR) sensor; when motion is detected near the sensor, the light brightness increases, and in the absence of motion, it remains dim. This automated setup not only enhances efficiency and safety but also supports smarter urban infrastructure management.

Keywords: IoT (Internet of Things), GSM (Global System for Mobile), LDR (Light Dependent Resistor), IR (infrared) sensors, Arduino Uno

1. Introduction

The Internet of Things (IoT) is a network of interconnected physical devices that enables real-time communication, remote sensing, and control. It integrates artificial intelligence for automation and analytics, enhancing system efficiency, accountability, and operational intelligence. IoT applications span across various domains such as smart homes, smart parking, smart highways, and smart lighting. In many regions, including our country, traditional street lighting using High-Intensity Discharge (HID) lamps results in significant energy wastage due to manual operation—often left ON during daylight or when roads are empty. This calls for a more sustainable and efficient solution. A smart street lighting system using LED lamps offers substantial benefits, including higher luminous efficacy, reduced energy consumption, lower maintenance costs, and enhanced durability. This system leverages LDRs (Light Dependent Resistors) to detect ambient light, relays for automated switching, and IR sensors to detect motion. When darkness is sensed, the system automatically switches ON the lights at dim brightness; upon detecting motion, the brightness increases. Furthermore, if a fault occurs in any light, a GSM module sends an alert message to the authorized mobile number, ensuring timely maintenance. This intelligent setup ensures energy conservation, reduces manual effort, and contributes to long-term environmental sustainability.

2. Implementation

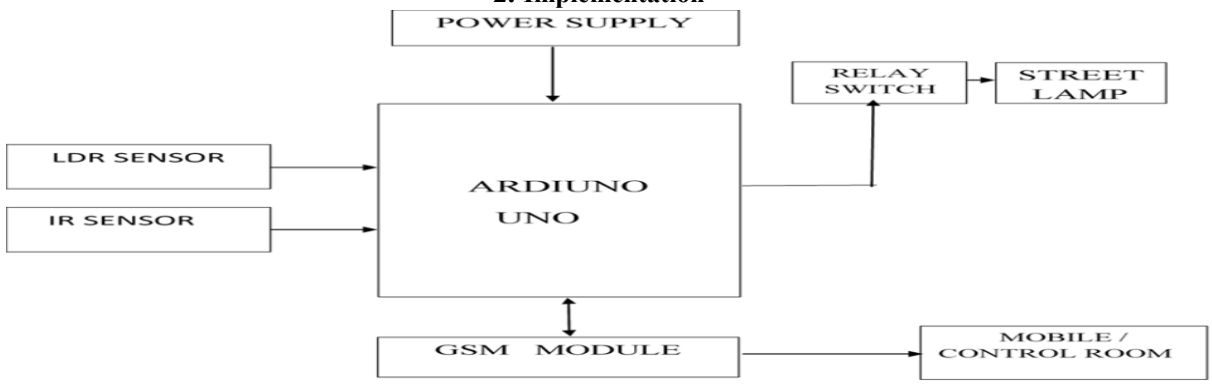


Figure 1: System Architecture

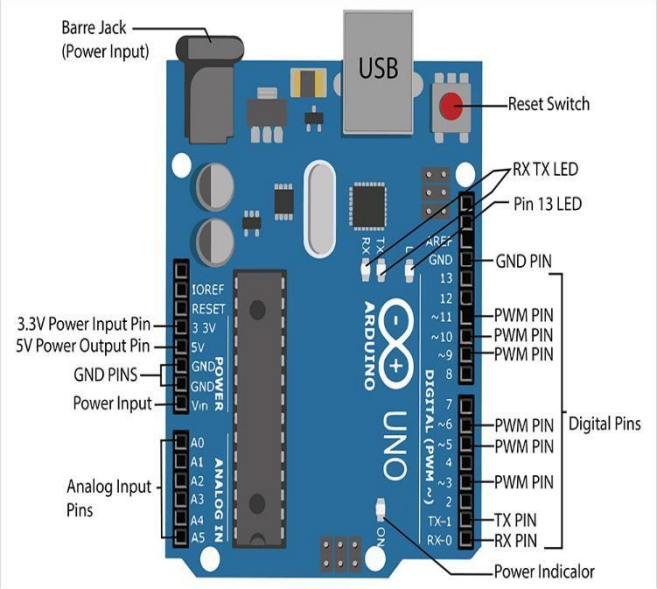
A. Arduino Uno

The Arduino Uno is a microcontroller board based on the ATmega328P microcontroller, which offers a variety of features for various applications. The board includes 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header, and a reset button, providing all the necessary components to start a project. Powering the Arduino Uno can be done either through a USB connection, an Alternating Current-to-Direct Current (AC-DC) converter, or a battery. The system uses SRAM for memory and Flash and EEPROM for storage.

To program the microcontroller, the Arduino project provides an Integrated Development Environment (IDE) that is based on C and C++ programming languages. This makes it accessible to both beginners and experienced developers.

- Applications of Arduino Uno
- Some of the most significant applications created with the Arduino Uno include:

- Embedded platforms
- Robotics
- Motion control of objects
- Parking lot counters



B. Light dependent resistor (LDR):

An LDR (Light Dependent Resistor), also known as a photoresistor, is a passive electronic component whose resistance varies depending on the intensity of light falling on it. The fundamental working principle of an LDR is photoconductivity—when light intensity increases, the resistance of the LDR decreases. This makes it ideal for light detection applications.

C. RELAY:

A relay is an electrical switch that uses an electromagnet to open or close a set of contacts, allowing it to control a circuit remotely. Traditionally, relays operated by using the electromagnetic principle, where a coil, when energized, creates a magnetic field that moves a contact arm to either make or break a connection. However, with advances in technology, other operating principles have been developed, such as solid-state relays, which perform switching functions without any moving parts. Solid-state relays use semiconductor components like transistors to switch the circuit.

Relays are electromechanical devices that are actuated by an electric current and can provide mechanical output or vice versa. They are used due to their simplicity, long life, and reliability. Some key applications of relays include:

- Isolating low voltage circuits from high voltage circuits
- Controlling multiple circuits
- Automatic changeover
- Controlling heavy electrical loads using microprocessors

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D. GSM:

The Global System for Mobile Communications (GSM) module, specifically the SIM900A Modem, is based on SIMCOM's Dual Band GSM SIM900A modem and operates on the 900MHz band. The SIM900A automatically scans both the 900MHz bands, and its frequency bands can be adjusted using AT Commands. The baud rate of the modem can be set from 1200 to 115200 using the AT button. The SIM900A is a compact, wireless module, ideal for M2M applications such as SMS, Voice, and Data transfer. The modem acts as an interface to connect a microcontroller with an RS232 chip (like the MAX232) and supports broad range, unregulated power supply connections via its onboard controlled power supply. This modem allows for audio calls, SMS sending/receiving, and answering incoming calls.

E. IR Sensor:

An infrared (IR) sensor is an electronic system that emits infrared light to detect objects in the environment. It typically includes an IR LED (Light Emitting Diode) and an IR photodiode. When these two components are combined, they can form a photocoupler. The IR LED emits infrared light, which is reflected by objects in the environment, and the photodiode detects the reflected light. This setup allows the sensor to detect objects, measure distances, or sense motion based on changes in the reflected infrared light.

3. Flow chart

Figure 2: Working flow chart

The Smart Street Light Control System operates by first reading the value of the IR sensor to detect motion. If motion is detected (IR value equals 1), the system then checks the LDR (Light Dependent Resistor) value. If the LDR value is greater than 400 lux, indicating sufficient ambient light, the light remains off. If the LDR value is less than 400 lux, the system checks the previous IR value. If motion is detected again, the light glows with high intensity; otherwise, it glows with dim light. If the light intensity does not meet the required level, the system sends a message to the authorized mobile number through the GSM module. If the system is functioning properly, it continues its operations, ensuring energy-efficient and responsive street lighting with motion detection and performance monitoring.

4. Results and discussion

As a result, this IoT-based automated streetlight infrastructure proves to be highly cost-effective. The project's primary goal is to save electricity by replacing traditional HID (high-intensity discharge) lamps with energy-efficient LED lights. The system continuously monitors the status of the streetlights, eliminating the need for manual staff inspections or periodic checks. This constant monitoring ensures accurate and real-time results, enhancing operational efficiency and further contributing to energy conservation.

5. Conclusion

In conclusion, this project's hardware and software architecture successfully meet the design objectives. The Arduino Uno was effectively used to create a working prototype of an automated street lighting system. By utilizing LDR and IR sensors as inputs, the system ensures energy savings by turning on the LED lights only when it is dark and when there is movement, thereby reducing power consumption. The automated street light control and fault detection system automatically adjusts the lighting based on these conditions. Additionally, the system is capable of quickly detecting light faults and sending warning messages to the controller, further enhancing the reliability and efficiency of the system.

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