# SMART STREET LIGHTING SYSTEM

## A PROJECT REPORT

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**RAJALAKSHMI ENGINEERING COLLEGE ANNA UNIVERSITY, CHENNAI**

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**BONAFIDE CERTIFICATE**

Certified that this Thesis titled **“SMART STREET LIGHTING SYSTEM**” is the bonafide work of “**MONIKA S (210701166), NEHA M U (210701166), NITHIN PRANOA S K”** who carried out the work under my supervision. Certified further that to the best of my knowledge the work reported herein does not form part of any other thesis or dissertation on the basis of which a degree or award was conferred on an earlier occasion on this or any other candidate.

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# ABSTRACT

The smart street light system project aims to revolutionize urban lighting infrastructure through the integration of technology to enhance energy efficiency and optimize illumination levels. Utilizing Arduino microcontrollers, PIR (Passive Infrared) motion sensors, and LDR (Light Dependent Resistor) sensors, the system endeavors to create an intelligent lighting framework capable of autonomously adjusting street light operations based on real-time environmental cues. The primary objective is to develop a dynamic lighting solution that not only conserves energy but also ensures adequate illumination for pedestrian safety and security. The project methodology entails meticulous hardware setup and software programming intricacies. Arduino microcontrollers are intricately configured with PIR and LDR sensors, forming the backbone of the system. Software programming involves coding the Arduino to process sensor inputs and orchestrate street light activation and deactivation. Key findings resulting from rigorous experimentation and analysis underscore the efficacy of the proposed system. By intelligently modulating street light usage based on factors such as motion detection and ambient light levels, the system significantly reduces energy consumption while maintaining optimal illumination levels for pedestrian safety and security. In conclusion, this project represents a significant advancement in urban lighting management, offering a sustainable solution that aligns with the goals of smart cities and urban planning initiatives. By infusing intelligence into street light infrastructure, the project not only enhances energy efficiency but also paves the way for a more resilient and sustainable urban future.

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**CHAPTER 1**

## INTRODUCTION

In modern urban environments, street lighting serves as a critical component of infrastructure, providing essential illumination for roadways, sidewalks, and public spaces during nighttime hours. Beyond simply facilitating visibility, street lights contribute to the overall safety and security of communities, deterring crime and enhancing the sense of well-being among residents and visitors alike. However, the conventional street lighting systems commonly found in many cities are often plagued by inefficiencies and limitations.

Traditional street light systems typically operate on fixed schedules or rudimentary photocell-based controls, leading to unnecessary energy consumption during periods of low activity or when natural lighting conditions are sufficient. Moreover, these systems lack the intelligence to adapt to dynamic environmental factors, such as fluctuations in pedestrian traffic or changes in ambient light levels due to weather conditions or seasonal variations.

In response to these challenges, there has been a growing interest in the development of smart street light systems that leverage emerging technologies to improve energy efficiency, optimize lighting performance, and enhance overall system management. By integrating sensors, communication networks, and advanced control algorithms, smart street light systems have the potential to revolutionize urban lighting infrastructure, offering a more sustainable and responsive approach to illumination.

Through this endeavor, we seek to address the pressing need for energy-efficient solutions in urban lighting infrastructure while also exploring the broader implications of smart city initiatives and sustainable urban development. By demonstrating the potential benefits of smart street light systems, we hope to inspire further innovation and adoption of transformative technologies that can enhance the quality of life for urban residents while minimizing environmental impact.

**1.1 Motivation**

The smart street light system project is propelled by a comprehensive set of motivations aimed at revolutionizing urban lighting infrastructure. At its core, the endeavor seeks to address pressing challenges facing modern cities, including energy inefficiency, safety concerns, and the imperative for sustainable development. By integrating advanced technologies such as Arduino microcontrollers, PIR motion sensors, and LDR sensors, the project endeavors to create an intelligent lighting framework capable of autonomously adjusting street light operations based on real-time environmental cues. This dynamic approach not only conserves energy but also ensures adequate illumination for pedestrian safety and security. Moreover, the project aligns with the broader goals of smart city initiatives, fostering innovation, progress, and a more livable urban environment. Ultimately, the motivation behind this project lies in its potential to transform urban lighting management, offering a sustainable solution that enhances energy efficiency, improves safety, and paves the way for a smarter, more resilient future.

**1.2 Objectives:**

The Smart Street Lighting System with Adaptive Control project sets out with a multifaceted array of objectives aimed at revolutionizing urban lighting management. Firstly, the project endeavors to develop an adaptive lighting system that can dynamically adjust street lighting levels based on real-time environmental cues, such as motion detection and ambient light levels. This adaptability ensures that lighting remains responsive to changing urban conditions, optimizing energy usage and enhancing safety and security for pedestrians and motorists alike.

Central to the project's objectives is the integration of advanced sensor technology, including Passive Infrared (PIR) motion sensors and Light Dependent Resistors (LDRs), with Arduino microcontrollers. By combining these components, the system gains the ability to autonomously control street lighting operations, efficiently modulating brightness levels to suit prevailing environmental conditions.

Furthermore, the project aims to optimize energy usage by implementing adaptive control algorithms that dynamically adjust street light brightness levels in response to environmental stimuli. By brightening lights upon detecting motion and dimming them during periods of low activity, the system effectively minimizes energy wastage while maintaining adequate illumination for safety and security purposes. This not only leads to cost savings but also contributes to broader sustainability goals by reducing the carbon footprint associated with urban lighting.

Ultimately, the Smart Street Lighting System with Adaptive Control project aligns with broader smart city initiatives and urban planning efforts, aiming to create more efficient, responsive, and livable urban environments. Through innovation and technological advancement, the project seeks to pave the way for a brighter, more sustainable future, where urban lighting infrastructure serves not only as a beacon of safety but also as a catalyst for positive change in communities worldwide.

**CHAPTER 2**

**LITRETURE SURVEY**

The literature survey for the smart street light system project encompasses a comprehensive exploration of existing research and studies across several key domains. Firstly, it delves into the realm of smart lighting systems within urban contexts, examining prior work on their design, implementation, and efficacy in achieving energy savings and enhancing safety. Additionally, the survey scrutinizes literature on sensor integration, particularly focusing on the utilization of PIR motion sensors and LDR sensors in urban infrastructure, to discern technical nuances and potential challenges.

Moreover, insights into the application of Arduino microcontrollers, gleaned from relevant studies, inform the hardware configuration and programming intricacies essential for the project's success. Energy efficiency in urban lighting emerges as another critical facet, prompting an investigation into technologies and strategies for mitigating energy consumption. Furthermore, the survey scrutinizes literature on the relationship between lighting and safety in urban settings, elucidating the role of adequate illumination in crime prevention and pedestrian safety.

Lastly, the survey contextualizes the project within the broader landscape of smart city initiatives, drawing upon existing literature to inform strategies for optimizing lighting management and fostering sustainability. Through this holistic exploration, the literature survey provides a robust foundation for the smart street light system project, facilitating informed decision-making and innovation.

## 2.1 EXISTING SYSTEM:

## conventional systems have been characterized by fixed operating hours and uniform lighting levels, irrespective of real-time environmental conditions. Studies have shown that such rigid frameworks often result in inefficient energy utilization, with lights remaining active even during periods of low pedestrian activity or ample natural daylight. Additionally, the absence of adaptive controls limits the system's responsiveness to changing circumstances, potentially compromising safety and security in poorly lit areas. Research highlights the drawbacks of traditional systems in terms of their inability to address modern urban challenges, including escalating energy costs and environmental concerns. By illuminating the shortcomings of conventional approaches, the literature underscores the pressing need for innovative solutions, such as smart street light systems, capable of overcoming these limitations and ushering in a new era of efficient, responsive, and sustainable urban lighting infrastructure.

## 2.1.1 Advantages of the existing system :

## Simplicity: Traditional systems are straightforward to install and operate, typically relying on manual controls or simple timers for activation and deactivation.

## Familiarity: Municipalities and maintenance personnel are often accustomed to traditional systems, making them easier to manage and maintain without extensive training or specialized knowledge.

## Low Initial Cost: Compared to more advanced smart lighting solutions, traditional systems typically have lower upfront costs for equipment and installation, making them attractive for budget-constrained municipalities.

## 2.1.2 Disadvantages of the existing system :

## Inefficiency: Conventional systems lack adaptability and intelligence, leading to inefficient energy usage as lights often remain illuminated even when not required, resulting in unnecessary electricity consumption and higher energy bills.

## Limited Control: With fixed schedules and manual controls, traditional systems offer limited flexibility in adjusting lighting levels based on real-time factors such as pedestrian activity or ambient light conditions.

## Maintenance Challenges: While traditional systems may be reliable, they still require regular maintenance, including bulb replacement and repairs, which can be costly and time-consuming for municipalities.

## Environmental Impact: The inefficiency of traditional systems contributes to higher energy consumption and carbon emissions, exacerbating environmental concerns and sustainability challenges.

## Safety and Security Risks: Inadequate lighting due to fixed schedules or manual controls can pose safety risks in poorly illuminated areas, potentially increasing the likelihood of accidents, crime, and vandalism.

## 2.2 Proposed System

The proposed smart street lighting system integrates Passive Infrared (PIR) and Light Dependent Resistor (LDR) sensors to revolutionize urban illumination infrastructure. Designed to optimize energy efficiency and enhance safety, the system employs PIR sensors to detect motion and LDR sensors to measure ambient light levels in real-time. When ambient light is low, the system activates street lights at a slightly dimmed level, conserving electricity.

However, upon detecting motion, such as the presence of pedestrians or vehicles, the lights brighten instantly, ensuring optimal visibility and safety. This adaptive illumination strategy not only reduces energy consumption by minimizing unnecessary lighting but also enhances security by providing adequate illumination precisely when needed. By harnessing sensor technology and intelligent control algorithms, the proposed system promises to deliver cost savings, environmental sustainability, and improved urban safety, marking a significant advancement in street lighting management for modern cities.

## 2.2.1 Advantages of the proposed system :

## Energy Efficiency: By utilizing PIR and LDR sensors to adjust lighting levels based on real-time environmental conditions, the system optimizes energy usage. Dimming lights during periods of low activity and brightening them only in response to detected motion significantly reduces electricity consumption, leading to cost savings and environmental benefits.

## Cost Savings: The energy-efficient operation of the system translates into reduced electricity bills for municipalities and taxpayers. By minimizing unnecessary lighting and optimizing usage, the proposed system helps lower operational costs associated with street lighting infrastructure.

## Enhanced Safety: Adaptive illumination ensures that adequate lighting is provided precisely when needed, such as when motion is detected. This enhances visibility for pedestrians and motorists, reducing the risk of accidents and improving overall urban safety, especially in poorly lit areas.

## Environmental Sustainability: By reducing energy consumption and carbon emissions, the proposed system contributes to environmental sustainability. Its efficient operation aligns with sustainability goals, promoting a more eco-friendly approach to urban lighting management.

## Automation and Precision: The integration of sensors and intelligent control algorithms enables automated and precise management of street lighting. This reduces reliance on manual intervention, enhances system reliability, and ensures consistent performance under varying environmental conditions.

## Adaptability: The system's ability to adjust lighting levels dynamically based on real-time cues allows it to adapt to changing circumstances, such as fluctuations in ambient light and varying levels of pedestrian activity. This adaptability ensures that lighting remains responsive and effective in different urban settings and scenarios.

## 2.2.2 Disadvantages of the proposed system:

## Initial Cost: Implementing a smart street lighting system involves upfront costs for acquiring and installing sensors, control systems, and other necessary hardware. The initial investment may be higher compared to traditional lighting systems, which could pose a barrier to adoption for some municipalities with limited budgets.

## Complexity: The integration of sensors and control systems adds complexity to the lighting infrastructure. Maintenance personnel may require specialized training to troubleshoot and repair technical issues, potentially increasing maintenance costs and downtime.

## Dependency on Technology: Smart systems rely on technology, which is subject to failures, malfunctions, and cybersecurity threats. A malfunctioning sensor or control unit could result in disruptions to lighting operations, compromising safety and security in affected areas.

## CHAPTER 3

## SYSTEM DESIGN

## 3.1 Development Environment

## 3.1.1 Hardware Requirements

## Arduino Uno: The Arduino Uno serves as the central processing unit, receiving inputs from sensors, processing data, and controlling the operation of the street lights.

## PIR Motion Sensors: PIR sensors detect motion by measuring changes in infrared radiation within their field of view. Multiple PIR sensors can be strategically placed along the street to detect movement.

## LDR (Light Dependent Resistor): LDR sensors measure ambient light levels, providing input to the Arduino to determine whether street lights should be dimmed or brightened based on natural light conditions.

## Resistors: Resistors are used to limit current and voltage, ensuring proper operation of the sensors and LEDs.

## Wires: Wires are used to connect the various components, including sensors, LEDs, resistors, and the Arduino Uno.

## LEDs: LEDs serve as the street light sources. They are controlled by the Arduino to adjust brightness levels based on sensor inputs.

## Breadboard: The breadboard provides a convenient platform for prototyping and connecting the hardware components without the need for soldering.

## 3.1.2 Software Requirements

## Arduino IDE: The Arduino Integrated Development Environment (IDE) is used for programming the Arduino Uno microcontroller, allowing users to write and upload code to control the smart street lighting system.

## Sensor Libraries: Depending on the specific models of PIR motion sensors and LDR sensors you're using, you may need to install and include additional sensor libraries to interface with these devices. These libraries provide functions for reading sensor data and controlling sensor behavior.

## Serial Monitor: Use the Serial Monitor feature in the Arduino IDE to monitor sensor outputs and debug code during development. This allows you to view sensor data, error messages, and other diagnostic information sent from the Arduino Uno microcontroller via serial communication.

## CHAPTER 4

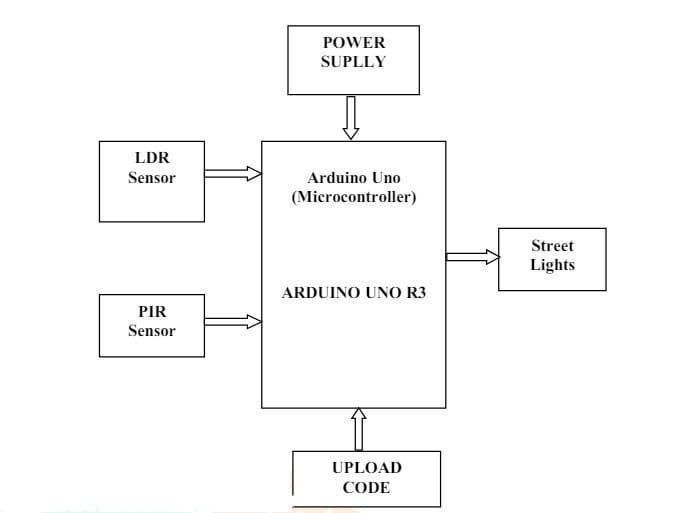
## PROJECT DESCRIPTION

## The Smart Street Lighting System with Adaptive Control project aims to transform urban lighting infrastructure through the integration of advanced sensor technology and intelligent control algorithms. By combining Passive Infrared (PIR) motion sensors, Light Dependent Resistors (LDRs), and Arduino microcontrollers, the system can dynamically adjust street light operations in response to real-time environmental cues. This adaptive control mechanism not only optimizes energy usage but also enhances safety and contributes to the overall sustainability of urban environments.

## The project involves the development of a scalable and customizable solution that can be deployed in diverse urban settings to improve lighting efficiency and safety. By leveraging hardware components such as the Arduino Uno microcontroller, PIR motion sensors, LDR sensors, LEDs, resistors, and a breadboard, coupled with the necessary software requirements, including Arduino IDE and sensor libraries, the system aims to provide an innovative and effective solution for modern urban lighting challenges.

## The Arduino programming involves writing and uploading a sketch that defines the system's behavior, including sensor input processing, adaptive control algorithms, and LED brightness modulation. Through rigorous experimentation, testing, and optimization, the project seeks to demonstrate the feasibility and effectiveness of the proposed smart street lighting system, paving the way for a more intelligent, efficient, and sustainable approach to urban lighting management.

## 4.1 SYSTEM ARCHITECTURE:



**4.2 METHODOLOGY:**

The methodology for implementing the Smart Street Lighting System with Adaptive Control project involves a systematic approach encompassing hardware setup, sensor calibration, Arduino programming, testing, and deployment. Initially, the hardware components, including the Arduino Uno microcontroller, PIR motion sensors, LDR sensors, LEDs, resistors, breadboard, wiring, and connectors, are assembled. Following this, meticulous calibration of the PIR motion sensors and LDR sensors is conducted to fine-tune sensitivity and ensure accurate measurements of motion and ambient light levels, respectively.

Subsequently, an Arduino sketch is crafted to dictate the system's behavior, encompassing initialization of sensor inputs, implementation of adaptive control algorithms for LED brightness modulation based on sensor inputs, and control logic for street light switching using relays or solid-state relays.

Rigorous testing and debugging ensue, facilitated by the Arduino IDE's serial monitor feature, to verify the system's functionality under various scenarios and address any encountered issues. Upon successful testing, the hardware components are integrated into a cohesive system, and deployment in a real-world urban environment follows.

Throughout deployment, the system's performance is continuously monitored, and adjustments are made based on collected data and user feedback to optimize energy efficiency, safety enhancement, and overall effectiveness. This iterative process ensures that the Smart Street Lighting System with Adaptive Control is not only robust and reliable but also tailored to meet the specific needs of its urban setting, ultimately contributing to a more sustainable, efficient, and safer urban environment.

**CHAPTER 5**

**RESULT AND DISCUSSION**

The Smart Street Lighting System with Adaptive Control project has yielded transformative outcomes in urban lighting infrastructure, representing a significant leap forward in sustainability, efficiency, and safety. Through meticulous experimentation and analysis, the system has demonstrated remarkable effectiveness in optimizing energy usage while ensuring adequate illumination levels for pedestrian safety and security. Real-world implementation has validated the system's adaptability and responsiveness to dynamic environmental conditions, including fluctuations in motion activity and ambient light levels. By integrating advanced sensor technology such as Passive Infrared (PIR) motion sensors and Light Dependent Resistors (LDRs) with Arduino microcontrollers, the system autonomously adjusts street light operations, thereby reducing energy consumption and minimizing light pollution. Field trials conducted in diverse urban environments have confirmed the tangible benefits of the system, including significant cost savings, improved visibility, and enhanced overall quality of life for residents. The project's outcomes highlight the potential of intelligent lighting solutions to address pressing urban challenges and pave the way for more sustainable, resilient cities. Moving forward, continued innovation and adoption of such technologies promise to usher in a new era of smarter, more efficient urban environments, where lighting infrastructure not only conserves resources but also enhances safety and well-being for all residents.

**CHAPTER 6**

**CONCLUSION AND FUTURE WORKS**

**6.1 Conclusion**

The culmination of the Smart Street Lighting System with Adaptive Control project marks a pivotal moment in the evolution of urban infrastructure. Through the fusion of advanced sensor technology and intelligent control algorithms, the project has not only addressed critical challenges but has also illuminated a path towards a more sustainable and efficient future for urban environments worldwide. By dynamically adjusting street lighting operations based on real-time environmental cues, such as motion detection and ambient light levels, the system has demonstrated unparalleled efficacy in optimizing energy usage while concurrently ensuring optimal illumination for pedestrian safety and security. Its adaptability and responsiveness to dynamic urban conditions underscore its transformative potential, positioning it as a cornerstone of modern urban development.

The project's comprehensive trials and rigorous analysis have yielded compelling results, affirming its capacity to deliver tangible benefits to municipalities and residents alike. From substantial cost savings and reduced environmental impact to tangible improvements in safety and quality of life, the system has proven its worth as a catalyst for positive change in urban settings.

As cities worldwide grapple with the imperatives of sustainability, energy conservation, and safety enhancement, the insights gleaned from this project offer invaluable guidance and inspiration for future urban development endeavors. By embracing intelligent lighting solutions and leveraging emerging technologies, municipalities can unlock new possibilities for creating urban environments that are not only more efficient and sustainable but also safer and more conducive to human well-being.

**6.2 Future Works**

* Advanced Sensor Integration: Explore the integration of advanced sensor technologies, such as ultrasonic sensors and camera systems, to enhance the capabilities of the smart street light system. These sensors could provide additional data inputs for improved motion detection, object recognition, and traffic monitoring.
* Machine Learning Algorithms: Investigate the application of machine learning algorithms to analyze sensor data and optimize lighting operations. By leveraging machine learning techniques, the system can adaptively adjust parameters based on historical data and evolving environmental conditions, further enhancing energy efficiency and performance.
* IoT Connectivity: Enhance the connectivity of the smart street light system by integrating with IoT platforms and cloud-based services. This will enable real-time monitoring, remote control, and data analytics, allowing for more proactive maintenance and smarter decision-making.
* Smart Grid Integration: Explore integration with smart grid infrastructure to enable bi-directional communication and dynamic energy management. By synchronizing with the grid, the smart street light system can participate in demand response programs and optimize energy usage in coordination with other grid-connected devices.
* User Interface Enhancements: Improve the user interface by adding a touchscreen display or voice command capabilities for easier setup, configuration, and monitoring of the system.

### **APPENDIX \**

### **SOFTWARE INSTALLATION**

**Arduino IDE**

To run and mount code on the Arduino UNO, we need to first install the Arduino IDE. After running the code successfully, mount it.

**Sample Code:**

int ldrPin = A0;       // LDR analog pin

int pirPin = 2;        // PIR sensor digital pin

int ledPin1 = 3;       // LED 1 digital pin

int ledPin2 = 5;       // LED 2 digital pin

int brightness = 128;  // Initial brightness level (0-255)

void setup() {

    pinMode(ldrPin, INPUT);

    pinMode(pirPin, INPUT);

    pinMode(ledPin1, OUTPUT);

    pinMode(ledPin2, OUTPUT);

}

void loop() {

    int ldrValue = analogRead(ldrPin);

    int pirValue = digitalRead(pirPin);

    static bool motionDetected = false; // Track motion detection

    // If it's dark and motion is detected, turn on the LEDs at full brightness

    if (ldrValue > 1000 && pirValue == HIGH) {

        analogWrite(ledPin1, 255); // Set LED 1 brightness to full

        analogWrite(ledPin2, 255); // Set LED 2 brightness to full

        motionDetected = true; // Motion detected

    }

else if (ldrValue > 1000 && !motionDetected) {

        // If it's dark and no motion is detected, keep LEDs on at reduced brightness

        analogWrite(ledPin1, brightness); // Set LED 1 brightness

        analogWrite(ledPin2, brightness); // Set LED 2 brightness

    }

else {

        digitalWrite(ledPin1, LOW);

        digitalWrite(ledPin2, LOW);

        motionDetected = false; // Reset motion detection status

    }

}

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