SMART STREET LIGHTS

MINI PROJECT REPORT

Submitted By

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BONAFIDE CERTIFICATE

Certified that this Report titled "**SMART STREET LIGHTS**" is the bonafide work of **SHREENIDHI G L (210701246),SONIYA V (210701254)** 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

With the advent of rapid development of the Internet of Things technology the horizon is bright and new innovative solutions in urban infrastructure began to appear at a slower pace with the domain of the street lighting systems in the forefront. The network powered system utilizes the road light poles equipped with sensors, which are connected to the internet of things central platform that centralizes the control of the street lamps. Each street lighting unit will have motion sensor, accompany with light sensor and network, thus enabling the lamps autonomous control and adaptive lighting. Such system functions through a process of assessing and controlling the intensity of the street lights on a basis of live environment input and human behavior. While cars are driving at times of low traffic, the lights turn low to save energy and become bright when motion is detected, enhancing the road safety by providing the adequate lighting at the times needed. These will ensure less, infrequent mechanical surveys and cheaper maintenance bills. The use of the Smart Street Light System, that is based on the IoT technology, to improve the energy efficiency, efficiency in managing the operations, and the safety of urban areas. This project discusses the framework, design thought, and the result of field deployments, which shows the power of IoT in transforming the conventional urban streetlights to sensible, sustainable and cost-effective solution.

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CHAPTER 1
INTRODUCTION

Municipal public lighting is a fundamental part of urban vital infrastructure and it has a vital role to play in regard to public safety, beautification of cities and their overall quality of life, which the climate emergency is now threatening. Although old lighting systems in streets are dealing with disadvantages such as too high energy consumption, frequently high maintenance costs, and given the conditions, a lack of adaptation to changing environmental circumstances. Downtowns that operate to become smarter and more eco-friendly put pressure on another innovative tool which help solve issues that arise.

By the means of IoT (Internet of Things) the path to street lighting optimization has been opened upon. Through linking sensors and communication stations with IoT technology, it becomes feasible to build street lighting that requires less energy and is also able to respond to changing environmental and circumstances conditions dynamically.

The subject of this undertaking is creating and applying an intelligent mesh network of street light system that provides improvement in efficiency and performance to street lights. The setup consists of street lights including movement sensors, light sensors as well as the wireless network modules which are connected to a common Internet of Things platform. The whole infrastructure enables you to instantly monitor, adjust the lighting conditions, and anticipate the maintenance, and therefore the electricity use is limited and the costs are significantly lowered.

CHAPTER 2
LITERATURE SURVEY

This The concept of smart street lighting systems utilizing IoT technology has garnered significant attention in recent years, with numerous studies exploring various aspects of design, implementation, and benefits. This literature survey reviews key contributions to the field, categorizing them into energy efficiency, adaptive control, fault detection and maintenance, and integration with smart city infrastructure.

Energy Efficiency

One of the primary motivations for developing smart street lighting systems is to enhance energy efficiency. Traditional street lighting systems operate at full capacity regardless of actual need, leading to substantial energy wastage. Several studies have demonstrated the potential for IoT-based systems to significantly reduce energy consumption. For instance, Wang et al. (2016) presented a smart street lighting system that uses wireless sensor networks (WSNs) to control street light intensity based on ambient light and pedestrian presence, achieving energy savings of up to 50% . Similarly, Khatavkar et al. (2017) implemented an adaptive lighting control system using Zigbee communication protocol, which resulted in notable reductions in electricity usage and operational costs .

Adaptive Control

Adaptive control mechanisms are crucial for optimizing street light performance. Various approaches have been proposed to dynamically adjust lighting levels based on real-time data. Zhang et al. (2018) developed a system that employs PIR (passive infrared) sensors and LDR (light-dependent resistors) to modulate light intensity according to pedestrian and vehicular movement . This approach ensures that street lights provide adequate illumination when needed and dim during periods of low activity, thus enhancing both energy efficiency and public safety. Another notable contribution by Singh et al. (2019) utilized machine learning algorithms to predict traffic patterns and adjust lighting accordingly, further improving the adaptability and responsiveness of the system .

Fault Detection and Maintenance

Efficient maintenance and fault detection are critical for the reliability of street lighting systems. IoT-based smart street lights offer significant advantages in this regard by enabling remote monitoring and diagnostics. Yang et al. (2017) proposed a system that uses IoT sensors to continuously monitor the operational status of street lights and report anomalies in real-time to a central management platform . This proactive approach reduces the need for manual inspections and allows for timely maintenance, thus lowering overall operational costs. Additionally, Tan et al. (2018) developed a fault detection algorithm that leverages data analytics to predict and identify potential failures before they occur, enhancing the system's reliability and longevity .

Integration with Smart City Infrastructure

The integration of smart street lighting systems with broader smart city infrastructure is a growing area of interest. Such integration can provide additional benefits such as improved traffic management, enhanced public safety, and better resource utilization. Hwang et al. (2019) explored the potential of integrating smart street lights with a city-wide IoT network, enabling the system to share data with other smart city applications like traffic control, emergency response, and environmental monitoring . This holistic approach not only maximizes the utility of the street lighting system but also contributes to the overall efficiency and sustainability of urban environments.

2.1 EXISTING SYSTEM

Traditional street lighting systems, which form a critical part of urban infrastructure, predominantly operate on fixed schedules and manual controls. These systems are characterized by several inefficiencies and limitations that hinder their performance and adaptability. Typically, they are programmed to turn on at dusk and off at dawn, with little to no adjustment based on actual lighting needs or environmental conditions. This inflexibility leads to substantial energy wastage as the lights remain fully operational even when there is minimal or no pedestrian or vehicular activity.

Moreover, traditional systems often lack the capability for real-time monitoring and remote management. Maintenance of these systems relies heavily on periodic manual inspections, which are labor-intensive and costly. When a malfunction occurs, such as a lamp failure or electrical fault, it may go unnoticed for extended periods, compromising public safety and increasing the likelihood of accidents or crimes in poorly lit areas. The reactive nature of maintenance not only escalates operational costs but also reduces the overall efficiency and reliability of the street lighting infrastructure.

The absence of data analytics and integration with other urban management systems further limits the effectiveness of traditional street lighting. Without the ability to gather and analyze usage patterns, these systems cannot adapt to changing conditions or optimize their performance.

In summary, while traditional street lighting systems provide basic illumination, they are plagued by significant drawbacks including high energy consumption, limited adaptability, costly maintenance, and lack of integration with broader urban infrastructure. These limitations underscore the need for more advanced, intelligent solutions that leverage IoT technology to create smart, responsive, and efficient street lighting systems.

CHAPTER 3

PROJECT DESCRIPTION

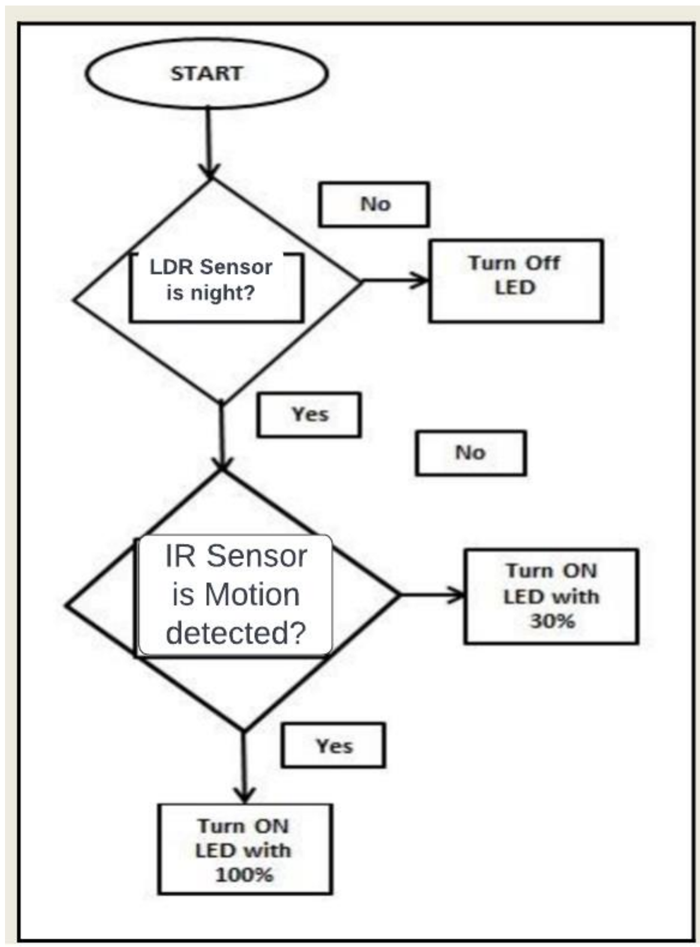

Fig 1 This Diagram shows the project description of smart street light

This This project aims to develop an IoT-based smart street lighting system using IR sensors, LDR (light-dependent resistor), and the ESP32 microcontroller to enhance energy efficiency, operational efficiency, and urban safety. The system is designed to dynamically adjust street light brightness based on real-time environmental conditions and human activity, thereby conserving energy and providing adequate illumination only when necessary. The workflow of the application is given in the Fig 1.

System Components

1. **IR Sensors**: Infrared sensors are employed to detect the presence of pedestrians and vehicles. These sensors trigger the street lights to increase their brightness when motion is detected in their vicinity, ensuring that the area is well-lit when needed for safety and visibility.

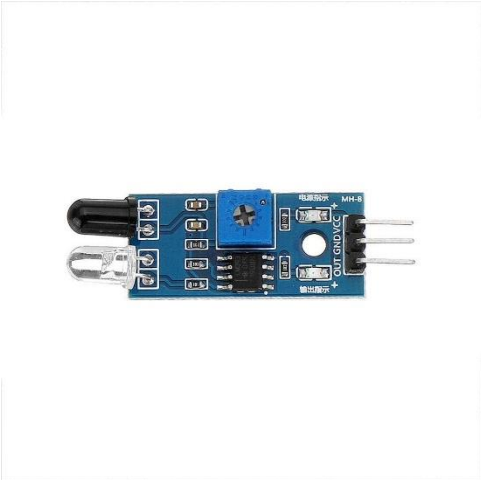

Fig 2 This Figure shows the IR Sensor

2. **LDR (Light-Dependent Resistor)**: The LDR is used to measure ambient light levels. It allows the system to adjust the brightness of the street lights based on natural light availability. During dusk or dawn, the lights will gradually adjust their brightness to maintain optimal lighting conditions, and they will dim or turn off when sufficient daylight is available.

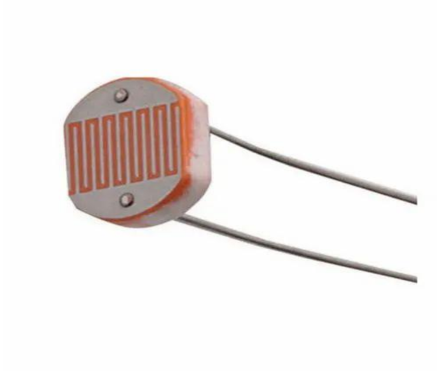

Fig 3 This Figure shows the LDR Sensor

3. **ESP32 Microcontroller**: The ESP32 microcontroller serves as the central processing unit of the system. It integrates the data from the IR sensors and LDR, processes this information, and controls the street lights accordingly. The ESP32 also facilitates communication with a central IoT platform for remote monitoring and control.

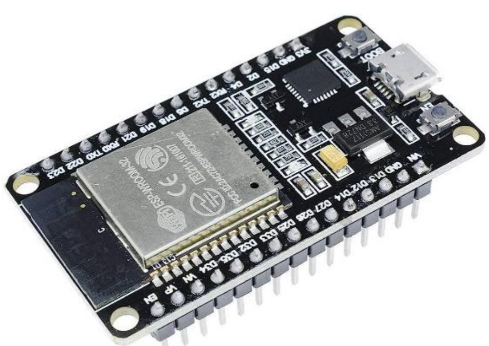

Fig 4 This Figure shows the ESP32 Microcontroller

4. **Resistors**: resistors play a crucial role in various aspects of the system. They are commonly used to limit the current flowing through LEDs, ensuring they operate within their specified ratings for longevity and efficiency. Additionally, resistors are employed in voltage dividers and sensor interfaces to scale down voltage levels and interface sensors with microcontrollers effectively

Fig 5 This Figure shows the resistors

5. **Jumper wires**: Jumper wires serve as essential components in IoT projects for smart street lighting, facilitating the seamless connection and communication between various modules, sensors, and microcontrollers within the system.

Fig 6 This Figure shows the resistors

System Operation

The smart street lighting system operates as follows:

1. **Ambient Light Detection**: The LDR continuously monitors the ambient light levels. When the natural light falls below a predefined threshold, the ESP32 microcontroller activates the street lights.
2. **Motion Detection**: The IR sensors are strategically placed to cover the areas around the street lights. When motion is detected, the sensors send signals to the ESP32, which increases the brightness of the street light to ensure the area is well-illuminated
3. **Adaptive Lighting Control**: Based on the data from the IR sensors and LDR, the ESP32 adjusts the brightness of the street lights dynamically. For instance, during periods of no detected motion and sufficient ambient light, the lights will dim to save energy. Conversely, in low-light conditions with detected motion, the lights will operate at full brightness.
4. **Remote Monitoring and Control**: The ESP32 is equipped with Wi-Fi capabilities, enabling it to connect to a central IoT platform. This platform allows for real-time monitoring of the street lights' status, energy consumption analytics, and remote control for maintenance and operational adjustments.

3.1 PROPOSED SYSTEM

The proposed IoT-based smart street lighting system leverages IR sensors, LDRs (light-dependent resistors), and the ESP32 microcontroller to create an adaptive and efficient lighting solution for urban areas. This system dynamically adjusts street light brightness based on real-time environmental conditions and human activity, significantly reducing energy consumption and operational costs. IR sensors detect the presence of pedestrians and vehicles, prompting the lights to brighten when motion is detected, while LDRs measure ambient light levels to adjust lighting based on natural light availability. The ESP32 microcontroller processes this data and communicates with a central IoT platform for remote monitoring and control, facilitating predictive maintenance and enhancing overall system reliability. The system's adaptive lighting control ensures optimal illumination only when necessary, improving urban safety and providing a scalable and flexible solution that can integrate with other smart city applications.

3.2 REQUIREMENTS

3.2.1 HARDWARE REQUIREMENTS

- Esp 32 Microcontroler
- Power Supply
- Wi-Fi
- LED
- IR Sensors
- LDR Sensor
- Laptop
- Jumper wires

3.2.2 SOFTWARE REQUIREMENTS

- Micropython
- Blynk IOT

3.3 ARCHITECTURE DIAGRAM

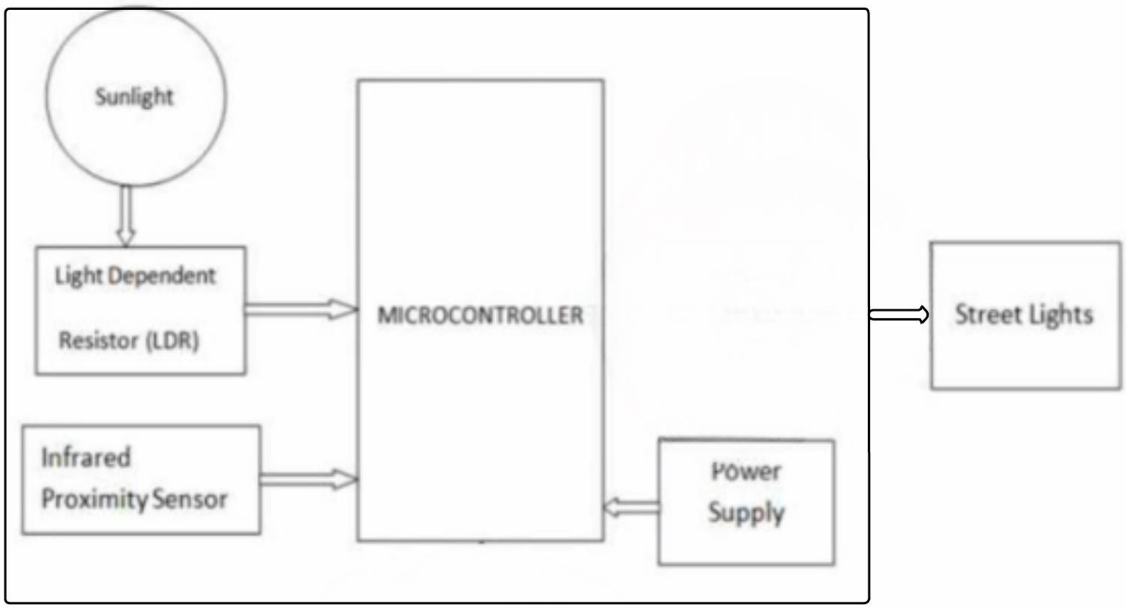

Fig7 Shows the architecture diagram

The architecture of the proposed IoT-based smart street lighting system shown in Fig 2 integrates several key components to create an adaptive and efficient solution. Each street light unit is equipped with IR sensors to detect motion and an LDR (light-dependent resistor) to measure ambient light levels. The ESP32 microcontroller processes data from these sensors to dynamically adjust the LED light's brightness. These microcontrollers communicate via a wireless network with a central IoT platform, which aggregates data from all units, performs analytics, and facilitates remote control. The platform provides a user interface for operators to monitor system performance, receive alerts, and manage the lights in real-time. This setup ensures optimal illumination, reduces energy consumption, and enhances operational efficiency, forming a scalable and flexible component of smart city infrastructure.

3.4 OUTPUT

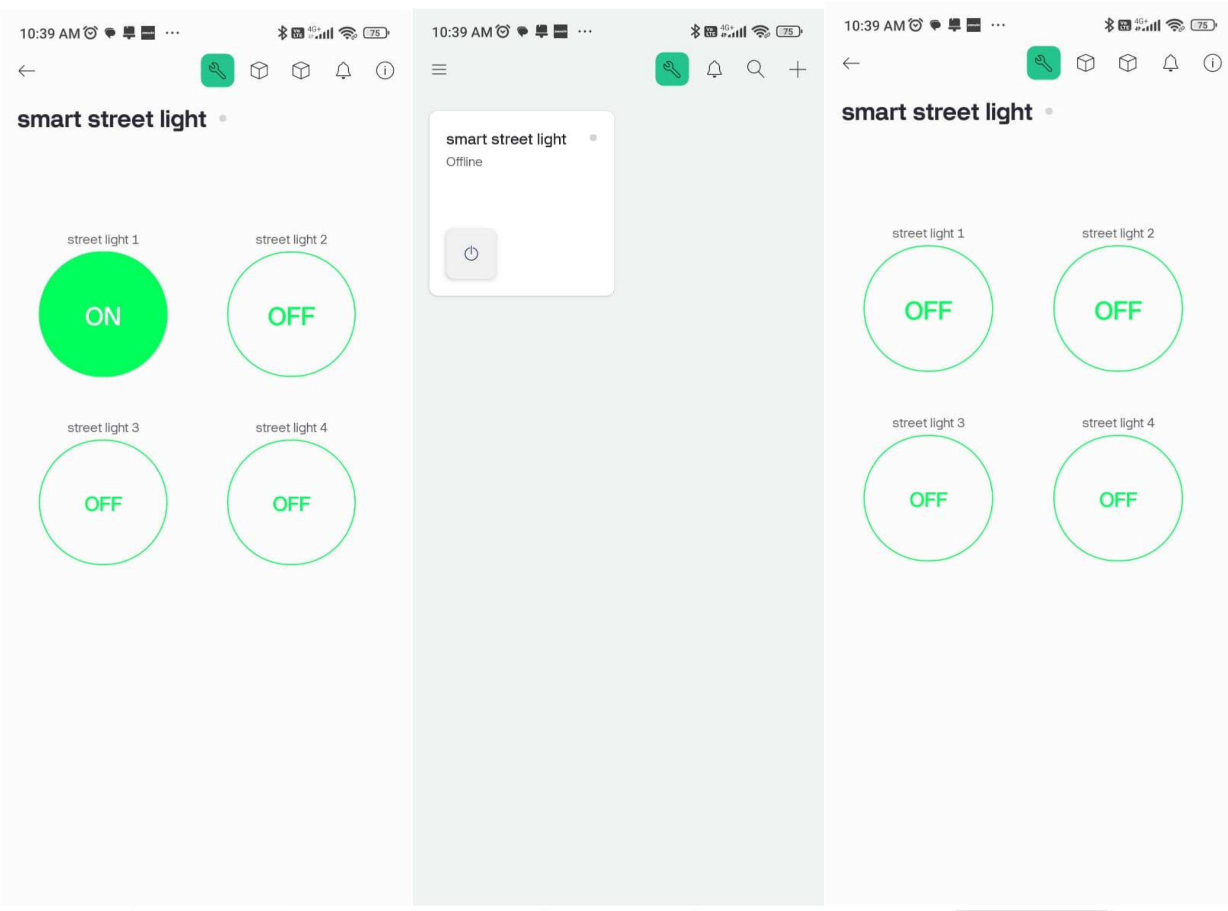

Fig 8 Shows the Blynk Module

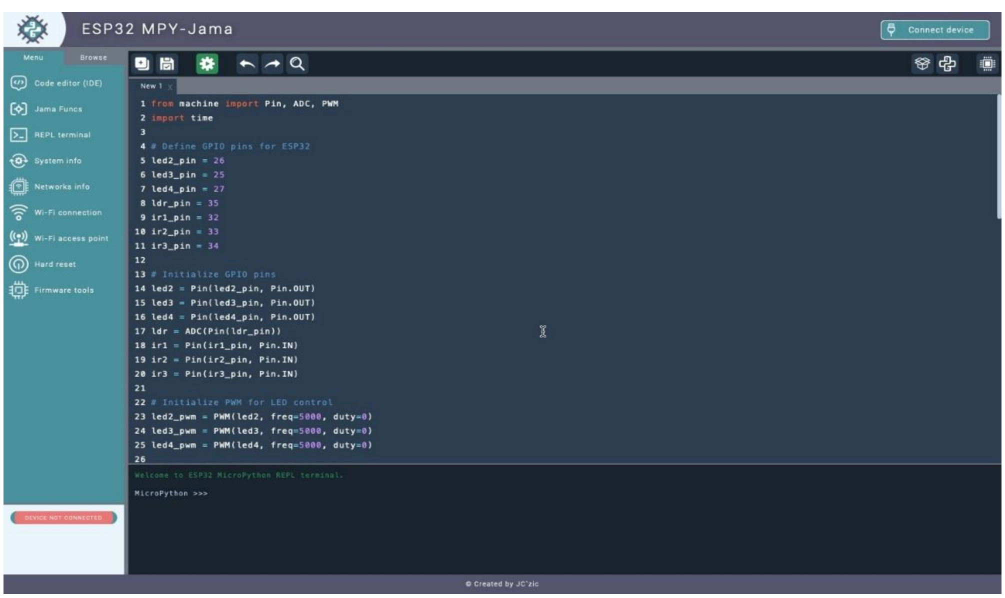

Fig 9 Shows the code implementation in Mycropython

CONNECTIONS:

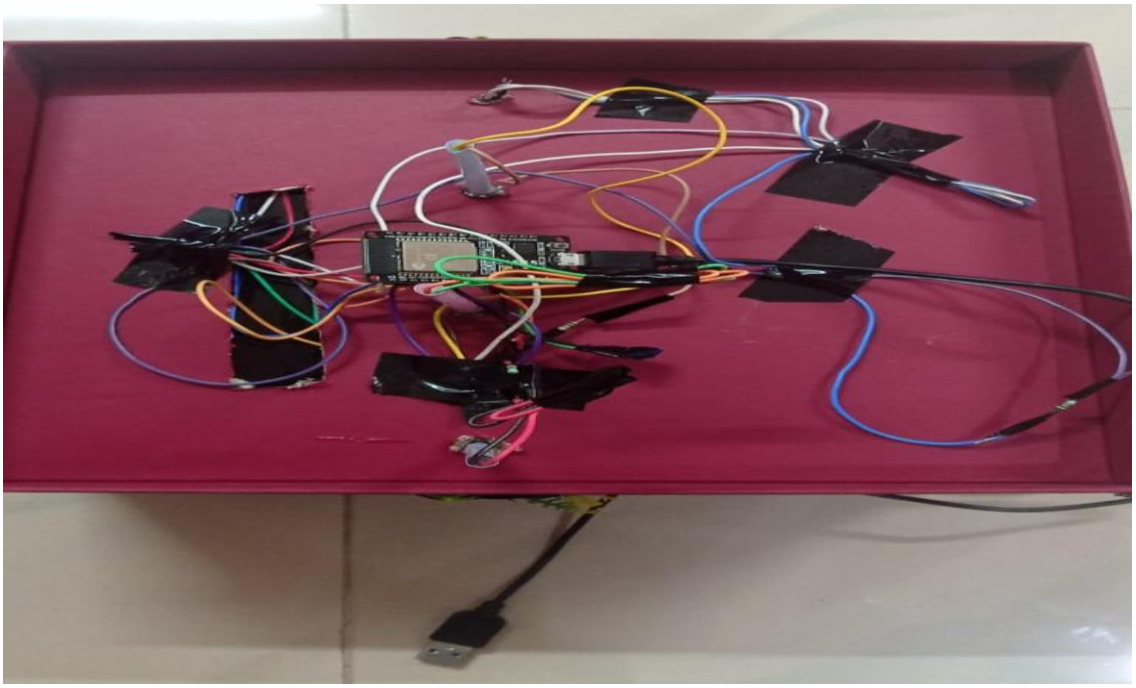

Fig 10 Shows the connections

Fig 6 Shows the final output

CHAPTER 4
CONCLUSION AND FUTURE WORK

This project indicates that IoT-based smart street lighting systems hold significant promise for enhancing energy efficiency, providing adaptive control, improving fault detection and maintenance, and integrating seamlessly with smart city infrastructure. By leveraging advanced sensors, communication technologies, and data analytics, these systems can transform traditional street lighting into a highly efficient, adaptive, and reliable component of urban infrastructure. This project builds on these foundations, aiming to develop and implement a comprehensive IoT-based smart street lighting system that addresses the key challenges and maximizes the benefits outlined in the reviewed studies.

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APPENDIX I

```
from machine import Pin, ADC, PWM
import time

# Define GPIO pins for ESP32
led2_pin = 26
led3_pin = 25
led4_pin = 27
ldr_pin = 35
ir1_pin = 32
ir2_pin = 33
ir3_pin = 34

# Initialize GPIO pins
led2 = Pin(led2_pin, Pin.OUT)
led3 = Pin(led3_pin, Pin.OUT)
led4 = Pin(led4_pin, Pin.OUT)
ldr = ADC(Pin(ldr_pin))
ir1 = Pin(ir1_pin, Pin.IN)
ir2 = Pin(ir2_pin, Pin.IN)
ir3 = Pin(ir3_pin, Pin.IN)

# Initialize PWM for LED control
led2_pwm = PWM(led2, freq=5000, duty=0)
led3_pwm = PWM(led3, freq=5000, duty=0)
led4_pwm = PWM(led4, freq=5000, duty=0)

# Function to set LED PWM duty cycle
def set_led_intensity(led_pwm, intensity):
    duty = int((intensity / 255) * 1023)  # Convert 0-255 range to 0-1023 range for PWM
    led_pwm.duty(duty)

while True:
    ldr_value = ldr.read()
    print("LDR Value:", ldr_value)

    if ldr_value < 500:
        # Low light condition, turn on LEDs
        set_led_intensity(led2_pwm, 128)  # Initial medium intensity
        set_led_intensity(led3_pwm, 128)  # Initial medium intensity
        set_led_intensity(led4_pwm, 128)  # Initial medium intensity
        print("LEDs are ON at medium intensity due to low light condition.")
```

```
    # Read IR sensor values
    ir1_value = ir1.value()
    ir2_value = ir2.value()
    ir3_value = ir3.value()
    print("IR1 Value:", ir1_value)
    print("IR2 Value:", ir2_value)
    print("IR3 Value:", ir3_value)

    # Check IR sensors and adjust LED intensities
    if ir1_value == 0:
        set_led_intensity(led3_pwm, 255)  # Max intensity
        print("IR1 detected close object. LED3 at max intensity.")
    else:
        set_led_intensity(led3_pwm, 128)  # Medium intensity

    if ir2_value == 0:
        set_led_intensity(led4_pwm, 255)  # Max intensity
        print("IR2 detected close object. LED4 at max intensity.")
    else:
        set_led_intensity(led4_pwm, 128)  # Medium intensity

    if ir3_value == 0:
        set_led_intensity(led2_pwm, 255)  # Max intensity
        print("IR3 detected close object. LED2 at max intensity.")
    else:
        set_led_intensity(led2_pwm, 128)  # Medium intensity
else:
    # Normal light condition, turn off LEDs
    led2_pwm.duty(0)
    led3_pwm.duty(0)
    led4_pwm.duty(0)
    print("LEDs are OFF due to normal light condition.")

time.sleep(1)
```

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