



Smart City Road Lights

A Smart, Energy-Efficient Street Lighting System

https://github.com/Thunder10046/Smart_City_road_lights

CSE 3200

Software Development Project II

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Addressing Inefficient Street Lighting

The Problem

Current road lights, especially in Rajshahi City, waste electricity by remaining on continuously, lacking dynamic adaptation to automation or road activity. This necessitates an intelligent system that balances visibility and energy usage.

Solution

Here, the proposal is to use a smart, energy-efficient street lighting system that dynamically adjusts brightness (automatically) based on sunlight and real-time object detection, optimizing both visibility and energy consumption.

Project Objectives



Cost-Effectiveness

Develop a lighting system that is affordable to implement and maintain.



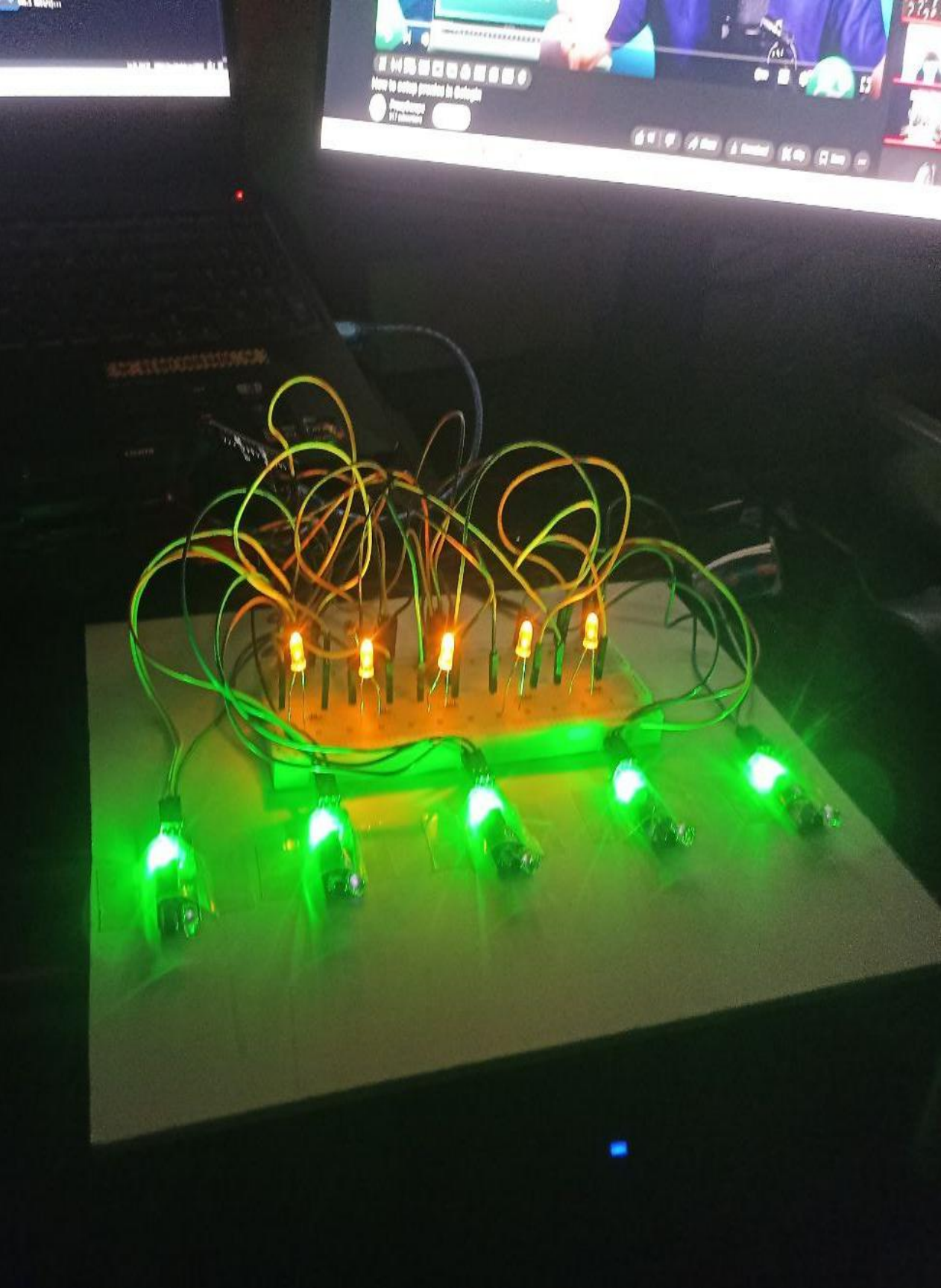
Energy-Saving

Minimize electricity consumption through intelligent control mechanisms.



Smart Lighting

Implement a system that adapts to environmental conditions and user needs.



Core Features of the Smart Lighting System



Day/Night Detection

Automatic detection using LDR (Light Dependent Resistor).



Motion-Based Control

Utilizing IR sensors for real-time object detection.

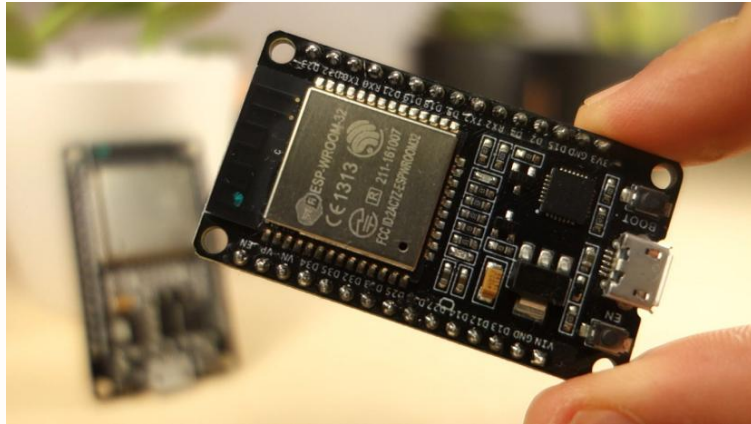


PWM Light Dimming

PWM-based light dimming and brightening for smooth control.

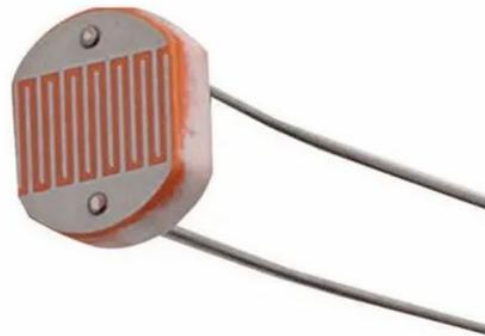
The smart lighting system incorporates automatic day/night detection using LDR sensors, motion-based control via IR sensors, and PWM-based light dimming for efficient energy management.

Hardware Components Overview



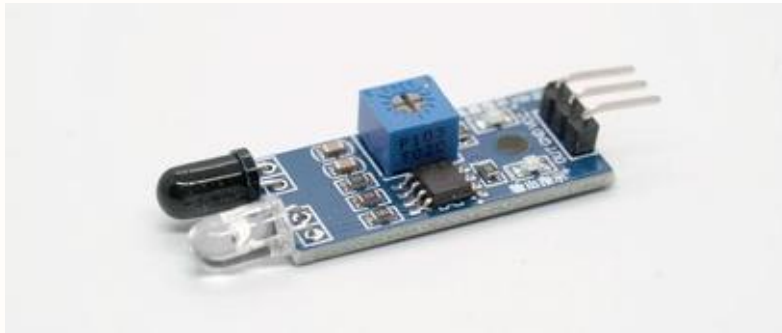
ESP32 Microcontroller

The brain of the system, responsible for processing sensor data and controlling LEDs.



LDR Sensor

Detects ambient light levels to determine day or night.



IR Sensors

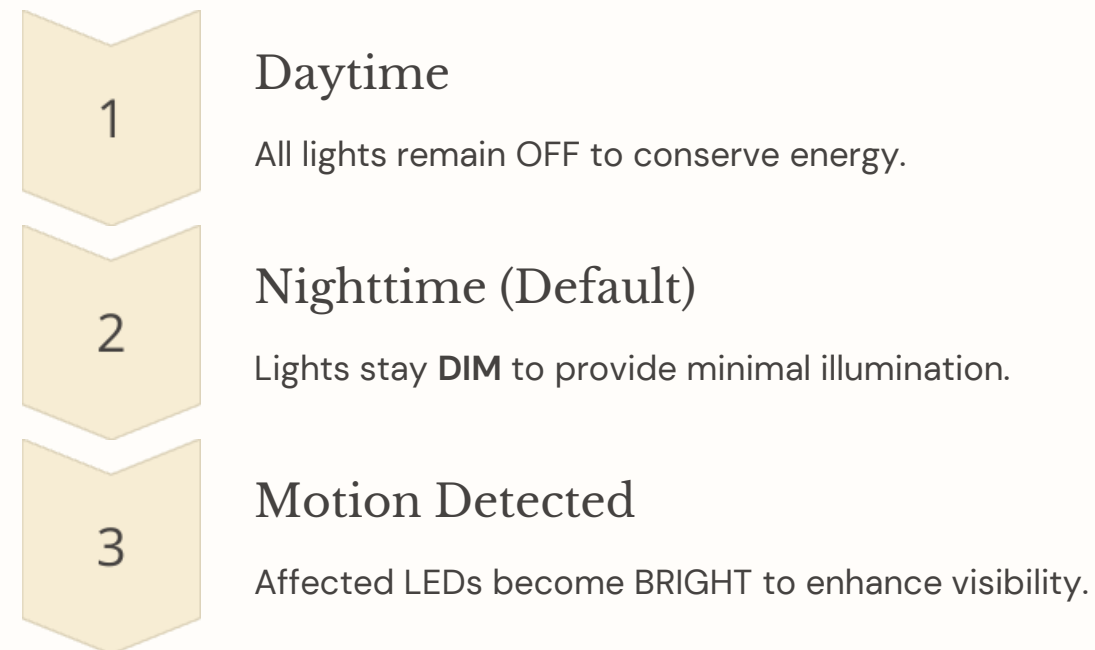
Detect motion of vehicles or pedestrians.



LEDs

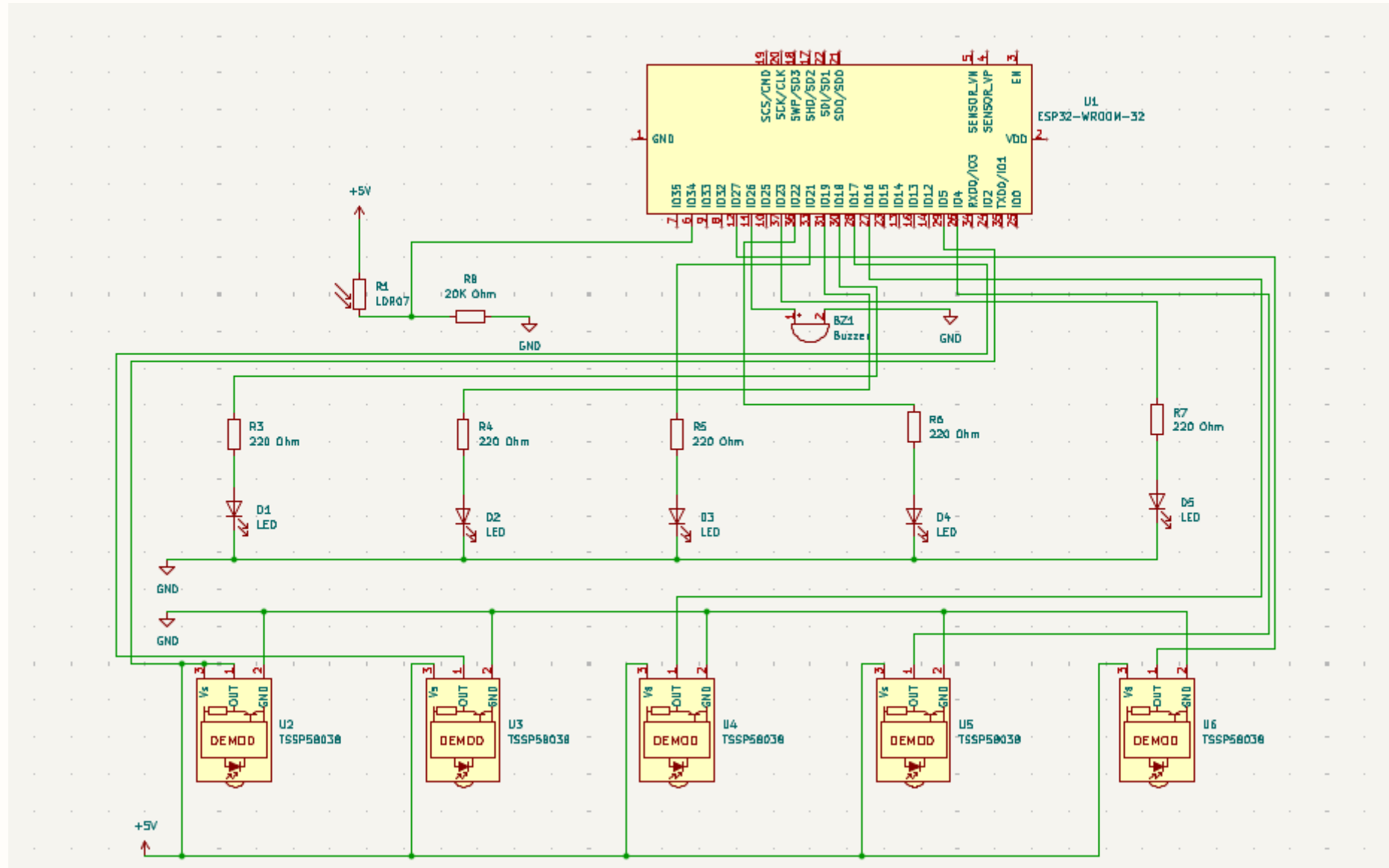
Provide illumination, with brightness controlled by PWM.

System Working Principle



During daytime, all lights are off. At night, lights default to a dim setting, brightening only when motion is detected by the IR sensors, ensuring efficient energy use and enhanced visibility.

Implementation (Schematic)



Implementation (Code)

```
int LDR = 34;                // LDR pin
int LedPins[] = {18, 19, 21, 22, 23}; // LED pins
int IRSensors[] = {5, 17, 16, 4, 27}; // IR sensor pins

int dimBrightness = 64;
int fullBrightness = 255;
int buzzer = 26;

const int pwmFreq = 5000;
const int pwmResolution = 8;

bool nightModePrev = false; // to detect transition

void setup() {
    Serial.begin(115200);

    pinMode(buzzer, OUTPUT);
    for (int i = 0; i < 5; i++) {
        pinMode(LedPins[i], OUTPUT);
        pinMode(IRSensors[i], INPUT);
        ledcSetup(i, pwmFreq, pwmResolution);
        ledcAttachPin(LedPins[i], i);
    }
}
```

```
void loop() {
    int ldrValue = analogRead(LDR);
    bool isNight = (ldrValue < 1000);

    if (!isNight) {
        // DAY MODE: Turn off all LEDs

        Serial.println("Day Mode: All LEDs OFF");
        for (int i = 0; i < 5; i++) {
            ledcWrite(i, 0);
        }
        nightModePrev = false; // reset flag
    }
    else {
        // NIGHT MODE

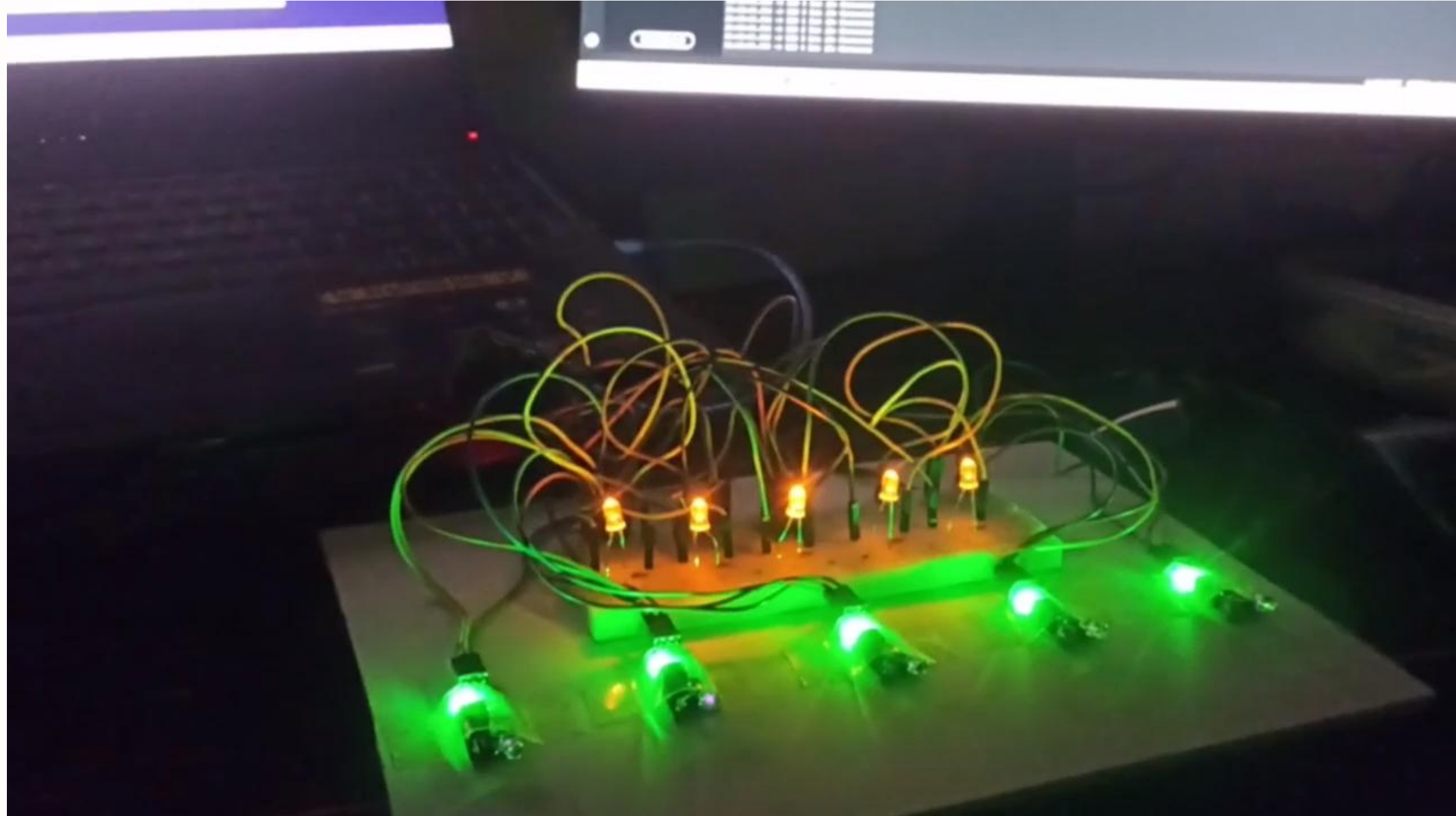
        if (!nightModePrev) {
            Serial.println("Night Mode ON → Buzzing once...");
            digitalWrite(buzzer, HIGH);
            delay(800); // Buzz for 1.5s
            digitalWrite(buzzer, LOW);
            nightModePrev = true;
            // now we won't buzz again until next day
        }

        for (int i = 0; i < 5; i++) {
            int sensor_status = digitalRead(IRSensors[i]);

            if (sensor_status == HIGH) {
                // No obstacle for this sensor, keep LED dim
                ledcWrite(i, dimBrightness);
                Serial.print("LED "); Serial.print(i); Serial.println(" Dim (No Obstacle)");
            }
            else {
                // Obstacle detected → instantly brighten corresponding LED
                Serial.print("Obstacle at IR "); Serial.print(i); Serial.println(" → Bright LED");
                ledcWrite(i, fullBrightness);
            }
        }
    }

    delay(100); // Prevent overwhelming the loop
}
```


Simulation



Key Benefits of the Smart Lighting System



Reduced Consumption

Significant reduction in energy consumption.



Smart Infrastructure

Contribution to future smart city initiatives.

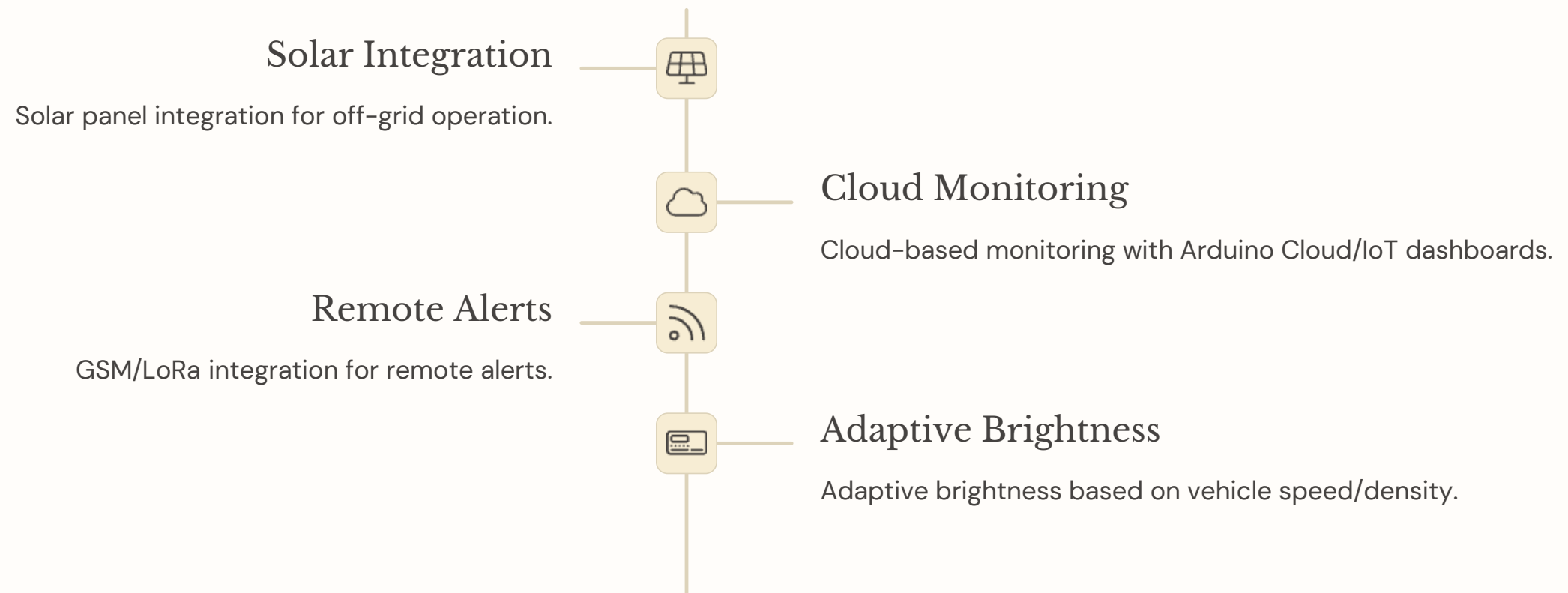


Scalable and Modular

Easy to scale and adapt to different environments.

The smart lighting system offers reduced energy consumption, contributes to smart infrastructure development, and is scalable and modular, making it a cost-effective and sustainable solution for city lights. In **Rajshahi**, we see lights are used inconveniently. By this implementation, energy can be saved and wastage is reduced. Electricity is used in convenient manner, also in an intelligent way.

Future Enhancements



Conclusion:

This smart city road lights project represents a step toward sustainable, intelligent city lighting by combining embedded systems, sensors, and automation. It is ready for future expansion and real-world deployment, offering a scalable and cost-effective solution for modern cities.