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IoT BASED SMART PUBLIC LIGHTING SYSTEM

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Abstract: We can observe that public lights are lit even during daytime in many areas leading to the inefficient usage and wastage of power consumption. Even though energy efficient LEDs are being used still in many places' timer controlled or manual turning on/off mechanisms are being employed to operate the lights which proved to be ineffective in saving energy. Hence using an IoT based system including solar panel to dynamically control the intensity of the lights will not only help to minimize the power consumption but also including a fault detection capability will help in real time monitoring of the lighting infrastructure and tracking the location using web application interface thereby reduces the maintenance time for repairing.

Key words: *Solar Panel, IoT, fault detection, real time monitoring*

1.Introduction

Street lights are a ubiquitous feature in urban landscapes, serve as more than just source of illumination. From the classic gas lamps of bygone eras to the energy efficient LEDs of today, the evolution of street lights reflects not only technological progress but also the changing needs and aspirations of society. As technology continues to advance, the traditional role of street lights has evolved beyond mere illumination. It is a fundamental component of urban infrastructure, plays a pivotal role in fostering public safety, enhancing visibility, and shaping the aesthetic character of our cities. So, to ensure safety and enhance energy efficiency we came up with this idea of Smart Public Lights which represent a transformative leap in urban lighting, converging technology and sustainability to redefine the role of traditional street illumination. Infused with intelligent features, these lights leverage advanced technologies like sensors and connectivity to enhance energy efficiency, reduce environmental impact, and contribute to safer, smarter cities. This integration marks a significant stride toward creating cities that are not only well-lit but also adaptive, sustainable, and technologically advanced.

2. Literature Survey

[1]"IoT based on Smart Traffic Lights and Streetlight System"

The evaluated approach integrates advanced technologies, comprising a Smart Traffic Signal Control System, a Smart Street Light System, and a Smart Motion Detection System. In the Smart Traffic Signal Control System, a traffic density sensor unit measures vehicle density on roads, employing a sophisticated algorithm to dynamically adjust traffic signals. The Smart Street Light System incorporates Passive Infrared (PIR) sensors and Light Dependent Resistors

(LDR) to automate street lights. During the day, the system remains inactive, and at night, it activates based on PIR sensors detecting movement. This intelligent approach minimizes energy wastage by illuminating only when necessary. The methodology's validation involves experiments and analysis, emphasizing the role of Internet of Things (IoT) technology in enhancing traffic and street light management, contributing to energy conservation and efficient urban infrastructure.

[2]"Smart Street Lamp System using LoRaWAN and Artificial Intelligence" Part-I

Utilizing the LoRaWAN wireless communication protocol, the approach establishes seamless transmission spanning over 500 meters between numerous LoRa nodes, notably the Heltec Cubecell HTCC-AB01 boards, and a central LoRaWAN gateway. Through the fusion of LoRaWAN, cloud computing servers, and Artificial Intelligence (AI) technologies, a sophisticated smart street light system is engineered. This system is adept at identifying four distinct object classes—pedestrian, bicycle, motorbike, and vehicle—and orchestrating the illumination of street lamps encircling the KMUTT football field during nocturnal periods. The strategic placement of multiple IP cameras facilitates data acquisition, with a Nvidia Jetson Nano AI board assuming the role of processing captured imagery. Upon detection of any specified object class by the AI system, the corresponding smart street lamp intensifies its brightness to full capacity. Conversely, in the absence of detected objects for a predetermined duration, the lamp's brightness diminishes by 50%, thereby conserving energy, unless further objects are detected within the specified timeframe.

[3]"IoT based Energy Efficient Smart Street Lighting Technique with Air Quality Monitoring"

The implementation of SSLS (Smart Street Light System) involves combining solar panels and piezoelectric transducers to generate electricity. LDR and IR sensors are used to control the intensity of LED streetlights. Streetlights operate at various intensity levels (100%, 50%, 40%, 30%, and 20%) based on the presence of vehicles, pedestrians, and sunlight. The system includes air quality sensors (MQ135) at every 6th streetlight. The data from their r quality sensors is transmitted to the authorities so as to allow them to take appropriate actions when air quality levels is abnormal to ensure safety of the public and also can take measures regarding the air quality.

[4]"Energy Efficient Smart Street Lighting System in Nagpur Smart City using IoT-A Case Study"

The paper details a case study of a smart lighting initiative implemented in Nagpur smart city, with a primary objective of mitigating the carbon footprint through reduced energy consumption. The project involved the replacement of 320 obsolete street lights with 63 energy-efficient LED lights equipped with a motion detection smart lighting system. Through the deployment of this intelligent street lighting infrastructure, Nagpur smart city achieved a remarkable reduction in energy consumption, amounting to approximately 55% per month. Notably, this substantial decrease was achieved without compromising on the prescribed lighting standards for pedestrians and vehicles, underscoring the effectiveness of the implemented solution.

[5]"Cost-Effective LED Dimming Driver with Single Chip Design for Smart Lighting System"

The methodology was employed for developing the LED dimming driver was meticulously crafted to address key parameters of efficiency, power output, and cost-effectiveness. An integral part of the process was the selection of the TSMC high-voltage process (TSMC 0.25um high voltage process) for chip fabrication, forming the groundwork for seamless integration of analog, power, and digital circuits. The design was the incorporated of a two-switch mechanism for brightness control, accommodating both auto and manual modes. The oscillator, features a frequency divisor, played a crucial role in generating clock signals, facilitating finetuned dimming control. The core design lay the PMOS current switch array, a key player in ensuring effective LED dimming and power control. The mixing-mode design not only streamlined integration but also paved the way for a unified solution, combining analog, power, and digital components into a single-chip marvel.

[6]"Smart Home Automation Using Intelligent Electricity Dispatch"

The approach followed is implementing a smart home automation system that integrates hardware and software components. The hardware includes D6T MEMS Thermal, Voltage, and Relay sensors connected to an Arduino Uno. Rule-based automation uses predefined rules for appliance control based on sensor readings and occupancy. Web-based automation allows remote control through serverdeployed web pages. App-based readings and occupancy. Web-based automation allows remote control through server-deployed web pages. App-based automation utilizes a Blynkconnected app with buttons and sliders for appliance control via the internet.

3.Methodology

To reduce the energy consumption and to build a smart lighting system we came up with this idea. Public lighting plays an important role by not only providing the light but also by provides safety and convenience to the public. By continuously monitoring the light levels we ensure that the lights are active only when necessary and we also take into considerations the weather conditions and also by using the IR sensor we will detect the movement and thereby adjusting the light intensity during the night time. We are also using the solar panel to utilize the solar energy. By continuously monitoring for the malfunctioning, we can provide real time tracking and if any defects are found an alert will be generated and will be immediately notified to the responsible electrical department enabling quicker response.

4.Hardware and Software Requirements

Raspberry Pi:

It is a small and single-board computer developed to promote the programming skills. One of the key features of the Raspberry Pi is its GPIO (General Purpose Input/Output) pins, which allows it to interact with the physical world by connecting to and controlling external devices such as sensors, actuators, LEDs, and motors. This capability makes the Raspberry Pi a popular choice for projects involving robotics, home automation, Internet of Things (IOT), and prototyping.

Figure 1: Raspberry Pi

LDR:

An LDR, or Light Dependent Resistor is a type of optoelectronic sensor that's used for detecting light

in the environment. It works by sensing changes in illumination and converting them into electrical signals which can be read off from its two terminals. This makes it an essential tool in many automation systems because it helps detect objects without any physical contact with them.

Figure 2: LDR

PIR SENSOR:

A passive infrared sensor (PIR) is an electronic device designed to detect infrared light emitted by objects. PIR sensors are commonly employed in motion detectors, security alarms, and automatic lighting systems.

Figure 3: PIR

DHT11:

The DHT11 is a basic, low-cost digital temperature and humidity sensor that is commonly used in electronics projects. The primary function of the DHT11 is to measure and provide accurate readings of temperature and humidity in the surrounding environment.

Figure 4: DHT11

GPS

A GPS module is a device that integrates a GPS receiver and associated circuitry into a single unit. It receives signals from GPS satellites to determine its own position (latitude, longitude, and altitude) and time information.

Figure 5: GPS module

ThingSpeak:

ThingSpeak is a versatile platform for prototyping and deploying IoT solutions, ranging from simple sensor monitoring applications to complex IoT systems with data analysis and automation capabilities

Flask:

Flask is a web framework designed for swiftly creating lightweight web apps, leveraging Flask Libraries. It's built upon the WSGI toolkit and Jinja2 templating engine. In the system, Flask serves to seamlessly connect the user interface with the backend models.

5. System Architecture

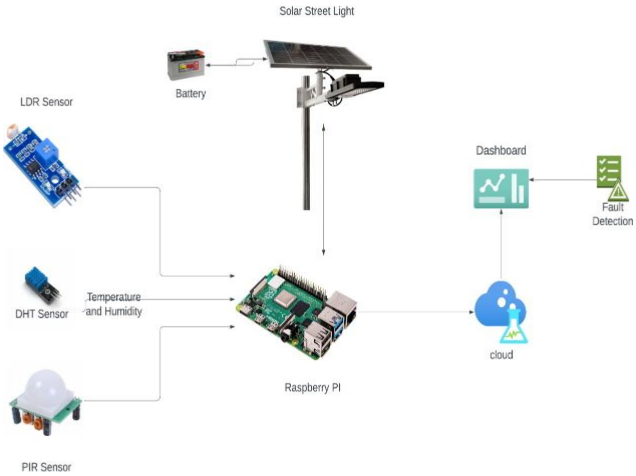

Figure 6: Proposed System Architecture

6. Working Principle

Light intensity detection:

The LDR (Light Dependent Resistor) sensor simultaneously monitors the light conditions. When the surrounding light level falls below a certain conditional value, it indicates low-light situation, the system triggers the system to switch on the street lights.

Weather Evaluation: Simultaneously, the temperature and weather sensors capture real-time environmental data, assessing factors such as temperature, humidity, and atmospheric conditions. This information is crucial for adaptive lighting strategies, enabling the system to adjust

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brightness levels based on weather patterns and ensuring energy efficiency.

Motion detection:

When the PIR sensor detects motion in its vicinity, signalling the presence of pedestrians or vehicles, the smart street lights intensify illumination in that specific area, enhancing safety and security.

Fault detection: In the fault detection, the health of each street light is continuously monitored through web application. The application is designed in such a way that user will be able to check the status of each light along with their location given by GPS in terms of latitude and longitudes. If irregularities are detected (i.e., if the light has not been detected by LDR sensor fixed to that particular LED) the notification should be sent to the concerned authorities showing that LED status is "off".

Location tracking and Messaging: In the event of a fault detection or any abnormality, an email will be sent to the maintenance team or relevant authorities via web application. This ensures swift responses to address issues and maintain the functionality of the street light network. the notification will be sent to the concerned authorities showing that LED status is "off" and pops an email message saying that the led at the particular location is not working.

7. Results

Figure 7: Object is detected and the lights get turned on

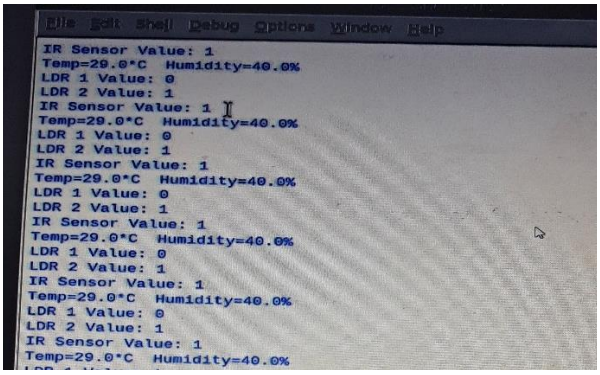

Figure 8: Output Screen

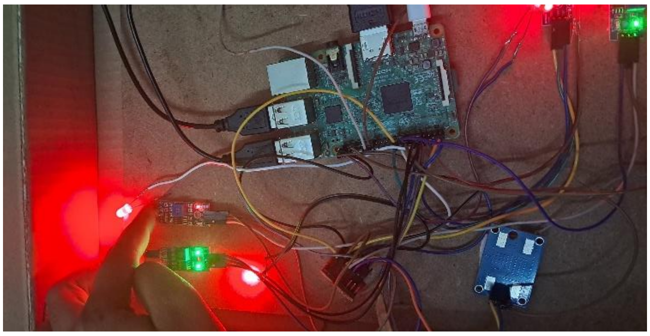

Figure 9: When light intensity is under threshold lights are lit

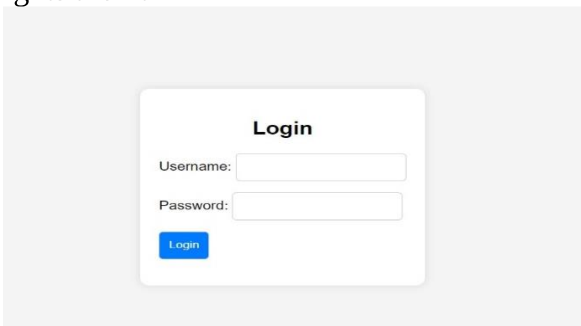

Figure 10: Login Page of Web application

Figure 11: Home page

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Features	Values
Temperature	28.0
Humidity	None
IR Value	None
LDR1 and LDR2 Value	None, None
Energy Generated	None
Location	None

Light not functioning

Figure 12: Features Page

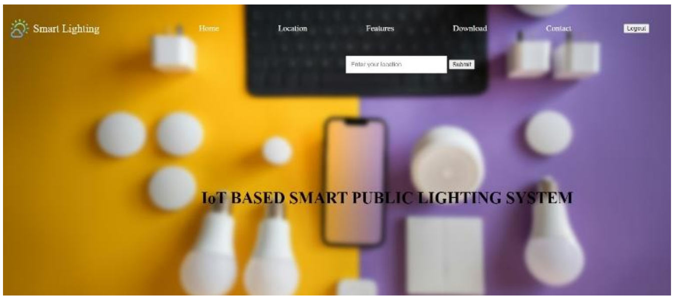

Figure 13: Select the location and features page will be displayed

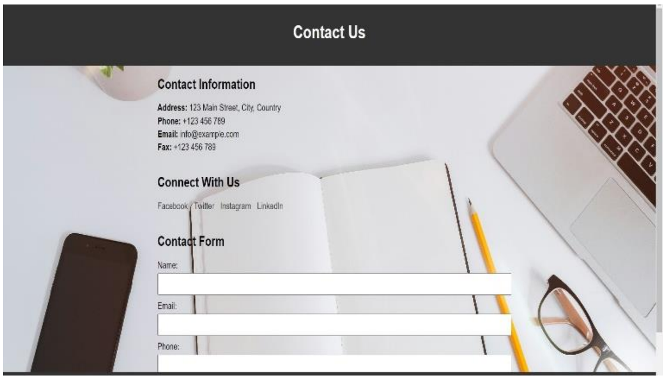

Figure 14: Contact Page

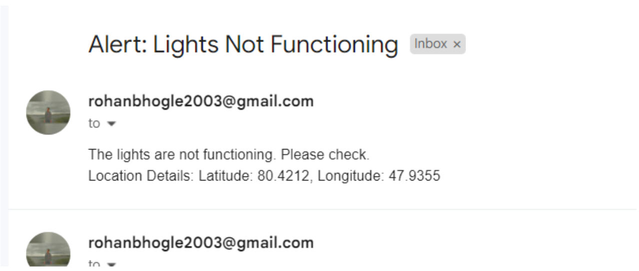

Figure 15: Email notification

8. Conclusion

The implementation of smart street lights with Raspberry Pi, LDR, IR, and weather sensors offers an energy-efficient and adaptive lighting solution. This integrated system optimizes brightness based on ambient light, detects human presence and optimizes LED lighting, identifies defective lights for prompt maintenance, and adjusts illumination according to weather conditions like foggy climates, windy, smoky times etc. Therefore, not only focusing on energy consumption but also ensuring that the safety of the public will never be compromised. The additional feature added to this is fault detection of LED that comes with location tracking (with GPS) and messaging which can be achieved by user friendly web application where user can login and check the status of each LED, whether is working status is “on” or “off”. This can avoid manual check-ups on LEDs health which is very time-consuming process. This project results in a sustainable and safer urban lighting infrastructure.

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