Urban Illuminance
(Unveiling Streetlight Anomalies)

Dr.M.S.Thanabal
PSNA College of Engineering and Technology
Dindigul,India

Asmath Banu S
Computer Science and Engineering
PSNA College of Engineering and Technology
Dindigul,India

Charumathi N
Computer Science and Engineering
PSNA College of Engineering and Technology
Dindigul,India

Chinthamani M
Computer Science and Engineering
PSNA College of Engineering and Technology
Dindigul,India

Sahithya R
Computer Science and Engineering
PSNA College of Engineering and Technology
Dindigul,India

Abstract- Street lighting systems play a vital role in urban infrastructure, ensuring safety and security for residents. However, faults in these systems often lead to energy wastage and compromised safety. Traditional fault detection methods are reactive and lack predictive capabilities, resulting in inefficient maintenance practices. To address these challenges, we propose an innovative IoT-enabled predictive fault detection system for street lights. Leveraging Arduino-based sensors, including Light Dependent Resistors (LDRs) and voltage/current sensors, alongside Node MCU for data transmission, our system continuously monitors street light performance metrics in real-time. Python-based predictive models, utilizing machine learning techniques such as Naïve Bayes, analyze historical sensor data to predict potential faults based on identified patterns. Upon detecting anomalies, alerts are sent to maintenance personnel through the Blynk app, enabling proactive maintenance and minimizing downtime. By combining IoT technology with predictive analytics, our system enhances urban infrastructure management, promoting sustainability and efficiency in street lighting operations.

Keywords— Street lighting systems, Urban infrastructure, Safety and security, Fault detection, Energy wastage, Predictive capabilities, Maintenance practices, IoT-enabled, Arduino-based sensors, Light Dependent Resistors (LDRs), Node MCU, Real-time monitoring, Python-based predictive models.

I.INTRODUCTION

Street lighting systems are crucial for urban infrastructure, providing illumination for roads and public spaces to enhance safety and community well-being. However, efficiently maintaining these systems presents challenges, with traditional fault detection methods often reactive and slow. To address these issues, our project proposes an innovative solution leveraging IoT and predictive analytics. By integrating IoT devices like Arduino sensors and NodeMCU for data transmission, our system continuously monitors street light performance metrics in real-time. Python-based predictive models analyze historical sensor data using machine learning, predicting potential faults to enable proactive maintenance. Through this approach, our system aims to revolutionize urban infrastructure management, improving efficiency and promoting sustainability. Our project introduces an IoT-enabled predictive fault detection system for street lights, offering a proactive approach to maintenance. By combining IoT technology with predictive analytics, we empower cities to identify and address faults promptly. Alerts sent to maintenance personnel through the Blynk app facilitate swift action, minimizing downtime and optimizing street lighting operations. This paper will explore the methodology, implementation, and potential implications of our system, highlighting its contribution to smarter, more sustainable urban infrastructure management.

I.OBJECTIVE

- Develop an IoT-enabled system for real-time monitoring of street light performance metrics.
- Implement predictive modeling techniques to anticipate potential faults in street lights.

- Integrate Arduino-based sensors and Node MCU for data collection and transmission.
- Enable proactive maintenance by generating alerts to notify maintenance personnel of detected anoma
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I. LITERATURE SURVEY

1. IoT-based Intelligent Streetlights system with fault tolerant mechanism using sensor fusion:

Saw Wei Chin, "IoT-based Intelligent Streetlights system with fault tolerant mechanism using sensor fusion " (2023).
Merits: Utilizes sensor fusion for accurate data and includes fault-tolerant mechanisms for reliability
Demerits: Potential complexity and increased cost.

2. Energy Conservation with Smart Street Light System Using IoT:

Tasfia Ibnat Tushi. "Energy Conservation with Smart Street Light System Using IoT“ (2023).
Merits: Improves energy efficiency by optimizing lighting schedules based on real-time data.
Demerits: No broader scope and more complex.

3. Detection of Anomalies in the Operation of a Road Lighting System Based on Data from Smart Electricity Meters:
Tomasz Smiałkowski. “Detection of Anomalies in the Operation of a Road Lighting System Based on Data from Smart Electricity Meters” (2023).
Merit: Utilizes smart meter data for precise anomaly detection.
Demerits: Uses information only from electricity meter.

4. Design and Implementation of Smart Street Light Automation and Fault Detection System:

Karthikeyan P, Dr. Karthik M. “Design and Implementation of Smart Street Light Automation and Fault Detection System” (2021).
Merit: Implements smart automation and fault detection for efficient street light management
Demerit: May lack detailed discussion on predictive modeling techniques and scalability of the system.

5. IoT based Automatic Damaged Street Light Fault Detection Management System:

Ashok Kumar Nanduri, Siva Kumar Kotamraju. “IoT based Automatic Damaged Street Light Fault Detection Management System” (2020)
Merit: Implements an IoT-based automatic system for detecting and managing damaged street lights, enhancing efficiency.
Demerit: May lack detailed discussion on predictive fault detection methods and scalability of the system

6. Sustainability in Street Lighting Operations:

Sharma, Anamika, and Nivedita Singh. "IoT based smart street lighting system." 2018 3rd International Conference for Convergence in Technology (I2CT). IEEE, 2018. Delgado, Abner, et al. "Towards energy-efficient street lighting management using IoT devices." IEEE Access 6 (2018): 57771-57783. Zhang, R., et al. "A survey on the emerging blockchain-based systems: Architecture, consensus, and future trends." IEEE Access 6 (2018): 50633-50665.

II.METHODOLOGY

The proposed system will be able to provide identification of the damaged/faulty street light automatically without any human intervention by employing appropriate components and sensors through IoT technology. It will be able to turn the street lights ON/OFF automatically by using sensors and a real time clock from the microcontroller. The progressive dimming of lights can be achieved automatically based on the vehicle's motion sensing to save energy. It sends the faulty street light's details to the Android application along with the location of the faulty bulb. It can collect the street light's working status in real time which can be accessed from the android application.

A. Advantages:

- It is cost effective and reliable
- It can control the brightness effectively based on vehicle's motion to save energy
- Automatic switching on/off of street lights can be achieved
- It can be incorporated in the streets in the nearer future for flawless faulty street bulb identification.
- The Street lights real time working status can be obtained
- Man power is considerably reduced

B. Block diagram:

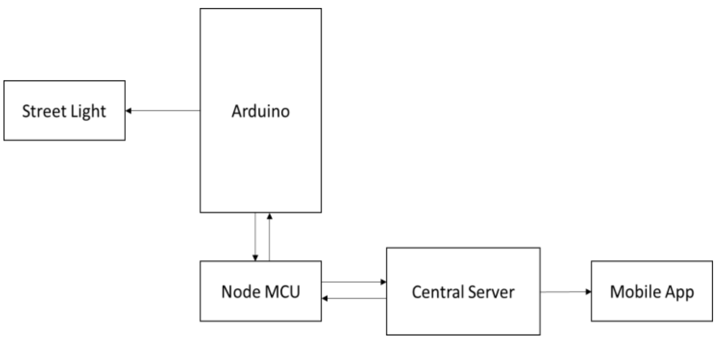

Fig. 1. Block diagram demonstrating working functionalities

Components:

- Sensor Module: Collects data on street light performance metrics.
- Communication Module: Transmits data to a centralized server using NodeMCU and Blynk.
- Data Analysis Module: Develops predictive models using Python and machine learning techniques.
- Alerting Module: Sends alerts and notifications based on model predictions.
- User Interface Module: Provides visualization of data and alerts through the Blynk app.

Interactions:

- Data flows from sensors to the centralized server for analysis.
- Predictive models generate alerts based on detected anomalies.
- Alerts are sent to maintenance personnel via the Blynk app.

III. HARDWARE DESCRIPTION

1. Arduino Uno:

Based on the Microchip ATmega328P microprocessor, Arduino.cc created the open-source Arduino Uno microcontroller board. A variety of expansion boards (shields) and other circuits can be connected to the board's digital and analog input/output (I/O) pins. The board has 6 analog I/O pins, 14 digital I/O pins, six of which can be used for PWM output, and it can be programmed using the Arduino IDE using a type B USB cable. Voltages between 7 and 20 volts can be supplied via a USB cable or an external 9-volt battery. It resembles the Leonardo and Nano Arduino microcontrollers. The hardware reference design is available on the Arduino website under a Creative Commons Attribution Share-Alike 2.5 license. There are designing and manufacturing files available for several hardware versions as well.

2. Current sensors:

The current sensor utilized in our project is a vital component for measuring the electrical current flowing through the street light circuits. This sensor is typically based on the Hall effect principle, which allows for non-intrusive and accurate measurement of current levels without disrupting the existing electrical connections. By integrating current sensors into the street light system, we can monitor the actual current consumption in real-time, enabling us to detect anomalies such as overcurrent
or undercurrent conditions.

3. Voltage sensors:

Alongside current sensors, voltage sensors are employed to monitor the voltage levels across different components of the street lighting infrastructure. These sensors provide essential insights into the electrical integrity and performance of the system, helping to identify potential faults such as voltage fluctuations or irregularities. Voltage sensors are designed to measure the voltage across specific points in the circuit, allowing us to assess the overall health and functionality of the street light fixtures.

4. LEDs:

A resistor is a passive electrical device with two terminals that creates electrical resistance to serve as a circuit element. Because they can release many watts of electrical energy as heat, high-power resistors can be used as generator test loads, power distribution systems, and motor controllers. Electrical limits to low voltage and generally to DC (not AC) power, difficulty to deliver consistent lighting from a pulsating DC or an AC electrical supply source, and lower maximum operating temperature and storage temperature are some of the downsides of LEDs.

5. Light dependent resistor sensor:

Other names for an LDR also referred to as a photo resistor, photocell, or photoconductor. It is a particular kind of resistor, and the resistance changes according to the amount of light that hits its surface. The resistance alters when light strikes the resistor. In many circuits where the need to detect the presence of light exists, these resistors are frequently used. The resistance and uses of these resistors are varied. For instance, the LDR can be used to turn ON a light when it is in the dark or to turn OFF a light when it is in the light. A typical light-dependent resistor has a resistance of 1 M Ohm in darkness and a resistance of a few M Ohm in brightness.

6. Software Requirement:

Software is employed in programming. The project cannot be operated if the Arduino is not programmed. We used Arduino software to program an Arduino UNO for the suggested system. With an editor, simulator, programmer, and other tools, it is a complete software development environment. The Arduino IDE has specific code organization guidelines to support the languages C and C++. Software for controlling Arduino was set up. The Arduino must then be connected to the computer's USB port. It must be connected to the computer using a USB cable.

IV.ANDROID APPLICATION FOR SMART STREET LIGHT CONTROL AND MONITORING

A. *Application:*

This application is for the administrator and the technical person who will be rectifying the lamp which is not operating properly. This app will show them the locations of the lamps which are not working properly and also the power consumption of the lamps and status of each lamp. The next page will appear allowing the user to navigate to other pages of their convenience. When the first option “Lamp status screen” is pressed, the screen moves to the next page containing the details of the lamp status.

The lamp status screen prompts the user to select a lamp whose status is to be checked. On selecting the lamp that particular lamp’s status alone is displayed. When we press back it returns back to the navigation screen. When the next option “Location screen” is pressed, the screen changes to the next page. The location screen has the option to add a location of the lamp by entering either its address or its latitude and longitude and also to view that location in the Google map. It also enables us to view our current location. When the last option “Energy consumption” is pressed, the energy consumption screen appears displaying the values of voltage, current and apparent and real power values.

The lamp status screen prompts the user to select a lamp whose status is to be checked. On selecting the lamp that particular lamp’s status alone is displayed, same as in the main application. When we press back it returns back to the navigation screen. When the next option “Location screen” is pressed, the screen changes to the next page. The location screen has the location of various fault lamps which can be viewed in the select location option. When a particular fault lamp location is selected from the select location option that address will be displayed in the text box and it can also be viewed in the Google maps. This also enables the user to view their current location. When the last option “Energy consumption” is pressed, the energy consumption screen appears displaying the values of voltage, current and apparent and real power values.

By this way, this app provides the user a convenient way to check the status of the lamp. If there is any fault in the lamp, it will send notification to the user and also it will send them a fault cleared message when that fault is corrected. This also provides a way to check the power consumed by the lamp

V.CONCLUSION

Nowadays resources (water, power, air, etc.) are very precious. This work focused to protect one such resource i.e. energy. Electricity is one of the major losses of energy. Using IoT the street lights ON/OFF is automated based on the weather condition. The working status of the street light is observed. The LDR sensor senses the environmental changes, the ON/OFF of the street lights is made automatically. Whenever the street light got damaged or not on during night time, the LDR sensor senses it and sends the notification to the authorized person that the light is damaged and the location (using GPS) where the light is damaged. It reduces human efforts, delays in fixing the issues. The automatic control of street lights is used to find the exact location when the street light gets damaged. Further, this can be implemented for all the street lamps in rural lamps. Pre-identification of damaged street lights is done based on the expiry of lamps.

VI.FUTURE SCOPE

In the nearer future, Addition of Solar Panels and replacing ac lamps by dc lamps can be made possible which can be used to power the street lights in the absence of main supply. Thus, it can act as a standalone system. Integration of camera for smart monitoring of the people to check whether the traffic rules are being followed can be done. Replacing the typically used microcontroller boards like ESP 32 in this case with Data Acquisition Cards (DAC) like My RIO microcontroller boards or PLC’s relatively can increase the longevity of the entire system.

ACKNOWLEDGEMENT

This paper is made possible through the help and support of blogs, and other media. Especially, we would like to dedicate our acknowledgment of gratitude toward the significant contributors. We want to thank PSNA College for the most support and encouragement. Furthermore, we would like to thank those who participated in the questionnaire as the data gathered could affect the outcome of this study. We appreciate their kindness in taking part of their time to answer the question with absolute seriousness. Finally, we sincerely thank our parents, family, and friends for their guidance and support. Finally, we would like to thank everyone who participated and supported this research, as their contributions and kindness were invaluable.

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