

Automated Fault Detection and Tracking in Street Lighting Networks

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Abstract— The exponential increase in the demand for electricity in recent decades has had a major effect on economies around the world, with developing nations having to deal with problems like load shedding. However, there are fewer natural resources available to generate electricity, so alternate solutions are required. Solar energy harvesting has become more widespread thanks to solar panels, but their use is limited because they need to be exposed to direct sunlight. Simultaneously, the emergence of sensor technology and automation has transformed day-to-day activities. Potential methods for energy harvesting include electric sensors, which produce energy through force, load, or pressure. As smart cities and societies develop further, street lighting will become an increasingly important part of urban infrastructure. In this regard, we suggest an Internet of Things-based Street light system.

Keywords— Electric sensors, LDR, Internet of Things, smart lights, automation of street lights, and smart societies.

I. INTRODUCTION

One of the biggest energy costs for municipalities globally is street lighting. Intelligent street lighting systems have become a feasible alternative in attempts to lessen this load and improve energy efficiency; they can cut expenses by up to 50% to 70% (Anupriya et al., 2014). Nevertheless, conventional systems frequently include inefficiencies, such as turning lights on only in response to the time of day or other external factors. Power is wasted as a result, especially on sunny or rainy days when there is only partial darkness. Furthermore, these systems' human operation adds even more inefficiencies [1]. When it comes to maintaining safety and averting accidents during nighttime transportation, street lighting is essential. But in the fast-paced world of today, it's easy to forget to manually turn on or off-street lights as needed. This paper offers an automated street light system as a solution to this problem, which will minimize power usage and do away with the requirement for labour. The installation of such a system offers an intelligent mechanism that reacts to motion detection without the need for human interaction, marking a significant leap in street lighting technology.[2] Street lighting system malfunctions can result in a number of problems, such as wasted electricity, higher maintenance expenses, and jeopardized public safety. Conventional techniques for fault identification and location monitoring frequently depend on labour-intensive, time-consuming, and error-prone manual inspection.

To address these challenges, the development of a fault detection and location tracking system for street lighting is essential. Such a system would leverage modern technology and data analytics to automate fault detection, streamline maintenance procedures, and improve overall system reliability. By implementing intelligent monitoring and diagnostic capabilities, municipalities and utility companies can enhance the efficiency and effectiveness of their street lighting operations.

II. LITERATURE SURVEY

- A Smart Street Lighting Control and Monitoring System is one suggested remedy; it uses Vehicle Ad-Hoc Networks (VANET) to automatically toggle lights based on vehicle presence in an effort to save electricity. A further deployment pertains to intelligent streetlights that utilize high-sensitivity sensors to enhance public safety and reduce waste and light pollution by adjusting intensity in response to movement detection. Furthermore, a proactive streetlamp monitoring system uses embedded energy meters and remote monitoring to provide timely bulb replacements along with warnings for maintenance and energy conservation.[3]
- Controlling Street lighting systems effectively is essential to cutting down on energy consumption and maintaining public safety. Intelligent street light management systems are taking the role of manual street light control methods in order to address issues like energy inefficiency and maintenance delays. A prevalent issue seen by numerous communities is the substantial energy wastage stemming from antiquated manual control mechanisms, which primarily rely on preset schedules to turn lights on and off, resulting in needless energy usage during times when natural light is abundant. Researchers have suggested creating wireless intelligent street lighting systems with cutting-edge phase-detection technology in order to overcome these difficulties. These systems use real-time data on ambient light levels and grid conditions to automate the process of turning lights on and off.[4]
- A wireless framework design was put forth by Nithya et al. [2] with the goal of automating street lights with little energy use. By using ZigBee wireless connection to provide data to a central station, their method entails intelligent management of lamp posts. Further energy savings are achieved through effective maintenance planning made possible by this unified data collecting. The goal of Srikanth et al. [3] was to create an automated street light system with remote control and ZigBee integration. By effectively identifying malfunctioning lights and cutting down on maintenance time, their method extends the life of the device and helps save energy. [5]
- The adoption of smart street lighting systems with AI-enabled features like light prediction has been spurred by the smart environment component of smart cities [5]. For example, in an effort to lower carbon emissions, Eindhoven, the Netherlands, used smart street lighting in 2014 with individual device management based on environmental parameters. Similar to this, Amsterdam's Smart City initiative optimizes energy use and carbon dioxide emissions by using remotely programmable light fixtures.[6]
- In addition to enhancing efficiency and safety, the installation of photocell sensors for automatic street lighting in Palasari Village, Tangerang Province, Banten, highlights the need of putting fault detection and location tracking systems in place for street lighting networks. This installation's literature evaluation emphasizes the value of automated electric management in improving operational effectiveness and lowering the possibility of electrical risks like electric shock and short circuits. The system makes use of photocell sensors to make sure that streetlights are turned on and off automatically in accordance with ambient light levels. This minimizes energy usage and power bills while simultaneously providing adequate lighting for cars and pedestrians.[7]
- This paper emphasizes the development of software in C, highlighting the versatility and widespread usage of this programming language in embedded systems development. The integration of an operating system during the software development phase demonstrates the importance of selecting appropriate software frameworks to facilitate the implementation of user functionality, such as threading capabilities. The proposed technique for automatically adjusting the brightness of street lamps using a wireless sensor network exemplifies the fusion of hardware and software to achieve intelligent control and energy conservation. Moreover, the paper discusses the role of different nodes within the wireless sensor network, such as collection nodes and cluster head nodes, in monitoring road traffic volume and ambient illumination.[8].
- The literature study lays the foundation for the development of defect detection and position tracking solutions by offering insightful information about the various methodologies and technological techniques investigated by researchers to address the issues and maximize the performance of street lighting systems.

One notable proposal highlighted in the review is the energy-efficient street lighting system incorporating Ethernet-based communication, LED lamp modules, and digital control driving systems.

III. PROPOSED SYSTEM

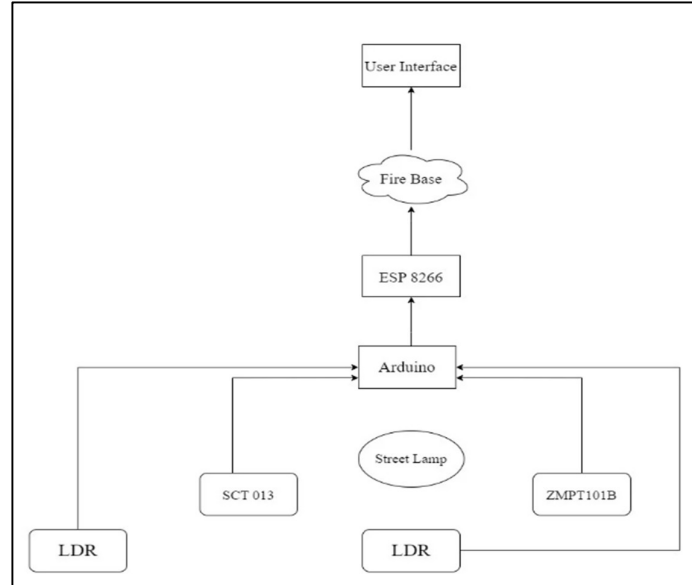


Fig 1. System Architecture

IV. METHODOLOGY

A variety of sensors and technologies are included in the street lighting fault detection and location tracking system's approach to guarantee thorough monitoring and efficient fault location identification. Throughout the street lighting network, potential transformers (PT), current and voltage sensors, and current transformers (CT) are systematically placed at essential locations such as distribution substations, feeder lines, and specific streetlight poles. These sensors gather and interpret sensor data to transform analog signals into digital format, allowing data acquisition devices to continuously monitor electrical parameters including voltage, current, and power usage in real-time.

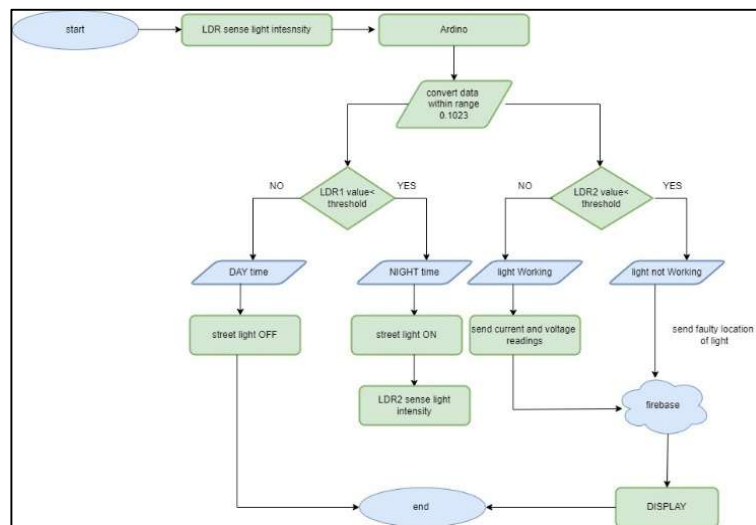


Fig 2. Flow of the system

The obtained data is then subjected to signal processing methods to remove outliers, filter noise, and extract pertinent features that allow for the identification of distinctive fault state signatures.

The central system uses the coordinates of the two reference bulbs to validate the exact location of the faulty streetlight by measuring the distances between the fault and each reference bulb. The system cross-references the validate coordinates with the database to confirm the fault location. Detailed alerts, including the exact location of the faulty streetlight are then generated and sent to the website or user.

Through the integration of these sensors and technologies, the proposed methodology enables efficient fault detection and location tracking in street lighting systems, enhancing reliability, safety, and operational efficiency across urban environment. The Fig 2. shows the working of our system.

V. RESULTS

The following images show the results from the website and the mobile application developed for monitoring the status of the street lights.

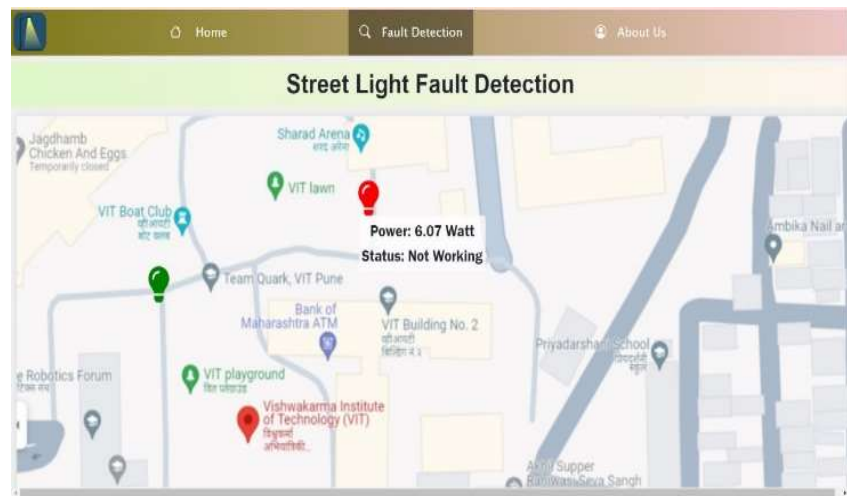


Fig 3. Status of the bulb: Not working

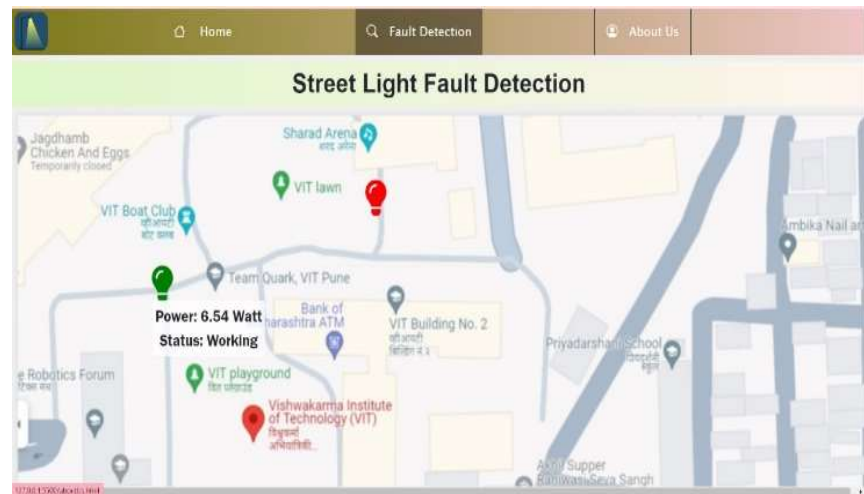


Fig 4. Status of the bulb: Working

Fig 3. shows the bulb in red, which indicates that the bulb is not working. It also shows the power consumption of that bulb. Fig 4. below shows the bulb in green which indicates that the bulb is working fine, along with its power consumption. A mobile application is also developed for easy monitoring of the location of street lights and its status.



Fig 5. Application showing the location of the bulb

VI. FUTURE SCOPE

The future scope for the project "Fault Detection and Location Tracking System for Street Lighting" encompasses several avenues for further development and enhancement. One potential direction involves the integration of advanced artificial intelligence (AI) and machine learning (ML) techniques for fault prediction and proactive maintenance. By analyzing historical data on street light performance and maintenance records, AI algorithms can identify patterns and trends indicative of impending faults, allowing for preemptive action to be taken before issues arise.

In general, the project's future scope will involve integrating cutting-edge analytics, sustainable practices, and developing technology continuously to build smarter, more resilient, and efficient street lighting systems for metropolitan settings. In order to foster innovation and tackle the changing demands of urban infrastructure management, it will be crucial to maintain cooperation with stakeholders, business partners, and academic institutions.

VII. CONCLUSION

Finally, our study has shown how electric sensors may be used to power street lights, which will further the development of smart cities and sustainable urban environments. We have created an electricity-efficient method of automating street lighting systems, lowering electricity expenses and dependency on conventional power sources by utilizing the energy produced by electric sensors. We have made it possible to remotely monitor and operate street lights by integrating Internet of Things (IoT) technology, which has improved operational flexibility and efficiency. Overall, our research represents a significant step towards the development of intelligent and energy-efficient street lighting systems. By leveraging innovative technologies and exploring new avenues for improvement, we aim to create safer, more sustainable, and environmentally friendly urban environments for future generations.

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