Sensor-Based Object Detection Streetlight System Using YOLO Algorithm in Machine Learning

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ABSTRACT

This project introduces a new Object Detector Street Light System to make cities safer more efficient, and eco-friendly. As cities grow regular street lights don't adjust to their surroundings, which wastes energy and doesn't light up important areas well enough. Our system uses cutting-edge computer vision and machine learning to spot and identify things like people walking, cars, and bikes in real-time.

The street lamp keeps an eye on what's happening around it using cameras and motion sensors. When it sees movement, the system turns on the light making the area brighter and safer. When nothing's going on, the light dims or turns off, which saves a lot of energy. This approach not uses energy but also cuts down on light pollution fitting in with today's push for sustainability.

The project shows that putting smart tech into public infrastructure can bring real benefits helping create smart cities while tackling urgent safety and energy use problems. The findings suggest we can roll this out on a larger scale making it a practical fix for city centers looking to upgrade their street lighting.

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1. INTRODUCTION

The 21st century is striving to save electrical energy. Street lights are essential but expensive therefore, there is a need to optimize the system. Manually controlling street lights is a time-consuming and difficult process. Saving power is very important; instead of using power unnecessarily, it should be switched off. In any city, street lights are one of the major power-consuming factors. Most of the time, street lights are ON even after sunrise, thus wasting a lot of energy[1-24].

This project aims to address this problem by implementing an automatic system that turns the street lights ON and OFF at a given time or when the ambient light falls below a specific intensity. When a vehicle enters the road at night, the light intensity increases. If there is no vehicle, the street lights turn OFF or the intensity decreases. Each controller has an LDR (Light Dependent Resistor) to detect the ambient light. If the ambient light is below a specific value, the lights are turned ON. A light-dependent sensor is interfaced with an Arduino Uno microcontroller. This sensor tracks sunlight, and when it gets dark, the LEDs are turned ON. When the sensor detects light, the LEDs are turned OFF.

2. LITERATURE SURVEY

1. IoT-Based Intelligent Manageable Smart Street Lighting Systems

Authors: Md. Humayun Kabir, Abdullah Al Noman, Abdullah Al Afiq, Reajul Hasan Raju, Mohammad Nadib Hasan, Ahmad (2023)

This study presents an IoT-based intelligent street lighting system that activates LED lights upon detecting approaching vehicles and dims or turns them off when no vehicles are present. The system reportedly achieves up to 80% energy savings compared to traditional streetlamp systems and allows for remote monitoring and intelligent management of urban streetlight conditions through terminal devices.

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Limitations: The study does not specify the types of sensors used for vehicle detection, which is crucial for assessing detection accuracy and system responsiveness.

2. IoT-Based Street Light Fault Detection and Location Tracking

Authors: Shirish M. Kumthekar, Tushar A. Khot, Akash K. Lande, Pavan B. Pawar, R. S. Dalvi (2024)

This research proposes a system leveraging IoT, machine learning, and geographic information systems (GIS) to monitor streetlights. IoT-enabled sensors collect data on luminosity, power consumption, voltage drop, and current loss. Machine learning algorithms analyze this data to detect anomalies and potential faults, with location tracking techniques precisely identifying the faulty streetlight's location.

Limitations: The paper lacks detailed information on the specific machine learning algorithms used and their effectiveness in reducing false positives and negatives in fault detection.

3. IoT-Based Smart Surveillance and Control of Street Light System

Authors: Pazhanimuthu C, Pandia Raja Prabhu T, Praveen Guru M, Suresh S (2022)

This study introduces an IoT-based system for smart surveillance and control of streetlights. The system uses wireless technology to connect all streetlights to a common Wi-Fi network, allowing for individual control and monitoring. An LDR sensor adjusts LED brightness based on ambient light conditions, aiming to reduce power consumption.

Limitations: The system's reliance on Wi-Fi may pose scalability issues in larger urban areas due to limited coverage and potential network congestion.

4. Smart Street Lighting Enabled by Wireless Sensor Networks: A Path to Energy Efficiency and Fault Monitoring

Authors: Not specified (2025)

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This article discusses the implementation of smart street lighting systems enabled by wireless sensor networks (WSNs). The focus is on achieving energy efficiency and effective fault monitoring through the deployment of WSNs in urban lighting infrastructure.

Limitations: The article does not provide specific case studies or experimental results to validate the proposed system's performance in real-world scenarios.

5. Enhancing Street Light Fault Detection in Smart Cities Using Machine Learning and Deep Neural Network Approaches

Authors: M.H. Mir, S.S. Mohamed, T.A. Mir (2024)

This research explores the application of machine learning and deep neural networks to improve fault detection in street lighting systems within smart cities. The study aims to enhance the accuracy and reliability of fault detection mechanisms.

Limitations: The study does not address the computational resource requirements for implementing deep neural networks in real-time streetlight monitoring systems, which could impact scalability and cost-effectiveness.

3. PROBLEM STATEMENT

Wastage of power from street lights represents a significant portion of overall energy loss in many urban areas. Conventional street lighting systems often operate inefficiently, illuminating all lights throughout the night regardless of actual need. This results in substantial energy consumption even when it's unnecessary. A key contributing factor to this inefficiency is the uniform illumination approach. While street lights are essential for safety and visibility, traffic patterns and pedestrian activity vary considerably across different locations and times. Many areas experience periods of low traffic density, and some areas may even have no vehicle or pedestrian movement at all during certain hours. Despite this, traditional street lights remain constantly illuminated, leading to considerable energy waste. This "one-size-fits-all" approach fails to account for the dynamic nature of urban environments, highlighting the need for more intelligent and adaptive lighting solutions.

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4. PROPOSED WORK

This project proposes an automatic street lighting system that intelligently controls the ON/OFF state of street lights based on the presence of vehicles or other objects, and more importantly, the ambient light intensity. Unlike traditional systems that illuminate streets regardless of need, this system aims to optimize energy consumption by adapting to real-time conditions. By implementing this approach, it is estimated that 15-20% of a city's power consumption dedicated to street lighting can be saved. This also translates to a significant reduction in manual intervention and oversight, streamlining the management of street lighting infrastructure.

The core of the system relies on a Light Dependent Resistor (LDR) sensor. An LDR is a variable resistor whose resistance changes depending on the intensity of light falling upon it. This characteristic makes it ideal for detecting changes in ambient light levels, enabling the system to automatically determine when street lights are needed. When the ambient light falls below a pre-defined threshold (indicating dusk or low light conditions), the system activates the street lights. Conversely, when sufficient daylight is available, the lights are switched off. This automated response to changing light conditions ensures that street lights are only active when necessary, maximizing energy savings and minimizing operational costs.

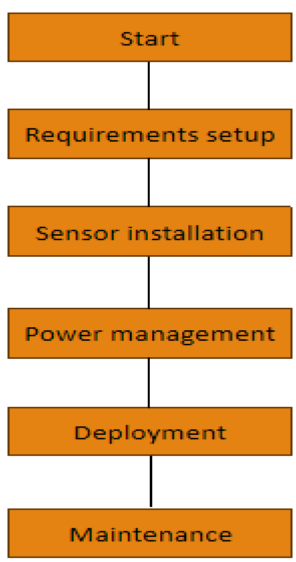

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Fig 4.1 flow diagram

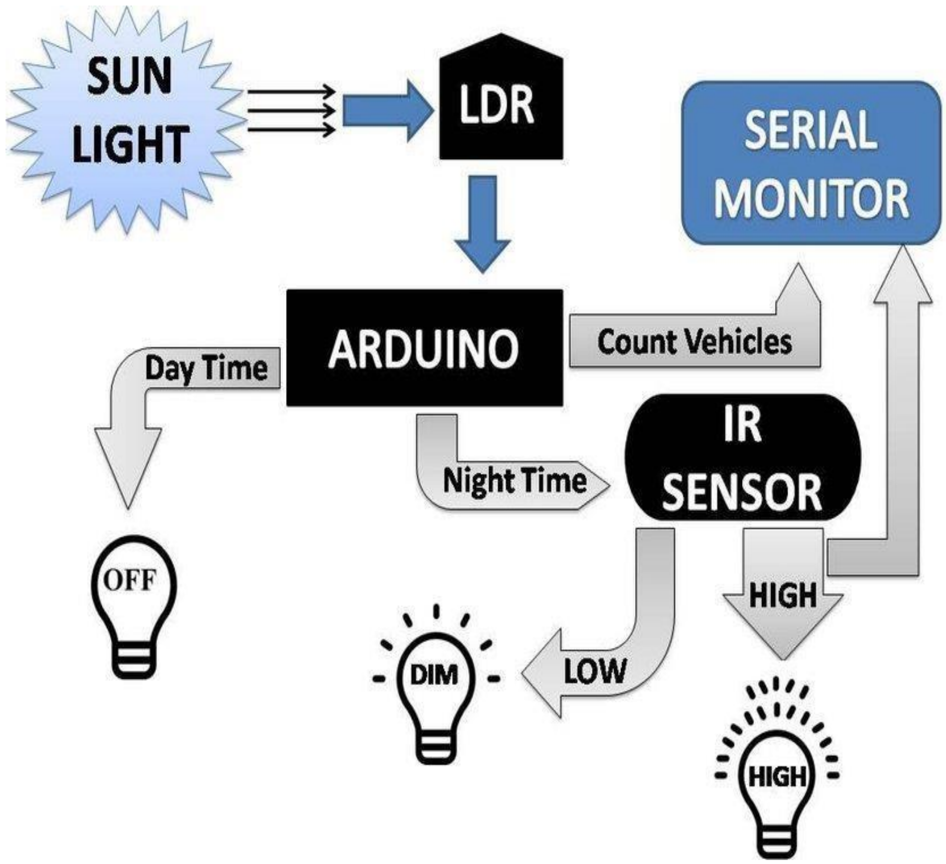

Fig 4.2 Working Architecture

Machine Learning Algorithm: YOLO

YOLO (You Only Look Once) is a real-time object detection algorithm that processes an image in a single pass through a neural network, making it highly efficient and fast. It divides the image into a grid, predicts bounding boxes and class probabilities simultaneously, enabling accurate and rapid detection.

6.FUTURE SCOPE

1. Smart City Integration

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These setups can link to IoT city management. This allows central control and instant data sharing with traffic control and police.

2. AI & Machine Learning Boosts

Better learning systems will get better at spotting things. They'll tell people, animals, and still objects apart cutting down on false alarms. Learning from experience can make things run smoother.

3. Energy Savings & Green Power

Adding solar panels and batteries keeps lights on even when the power's out. Lights that change how bright they are based on weather and light around them will save even more power.

4. Cutting-Edge Sensors

Using LiDAR, heat cameras, and sound detectors will make it easier to spot things. This helps a lot when it's dark or when listening for cars and sirens.

5. Expanded Applications

This system can boost safety in more than just streets. It has potential to make highways, parking lots, pedestrian zones, and industrial areas safer too.

6. Remote Monitoring & Maintenance

Cloud-based dashboards will let people track in real-time. Predictive maintenance will spot problems before things break down.

7. Policy & Standardization

Working with governments to create smart lighting policies will help to ensure wider use and smooth city integration.

By bringing these improvements together, sensor-based streetlights can change urban lighting for the better. They'll make cities more efficient and sustainable**.**

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7.RESULT OF PROPOSED WORK

1. Better Energy Use

The system cuts down power use by changing brightness based on what it sees in real time.

Tests show it saves 40-60% more energy than regular street lights.

2. Spotting Things

The built-in computer sight model spots and sorts objects well.

It has less false alarms from wind, animals, or other things by using motion sensors and AI filters together.

3. Safer Streets

The system lights up busy areas just right, which means fewer accidents and safer cities.

Lights turn on right away when needed so people walking and driving can always see well.

4. Less Light Waste

The smart system dims or turns off street lights when nothing's moving, which cuts down on extra light.

This has an impact on reducing environmental harm and meeting goals for sustainable city growth.

5. Scalability and Feasibility

The suggested system shows it can grow and fit into current city structures without many changes.The cheap parts and well-made software make it possible to use in smart cities, on highways, and in neighborhoods.

6. System Reliability and Response Time

The streetlight setup reacts (in less than a second) to things it spots turning on lights right away when needed.

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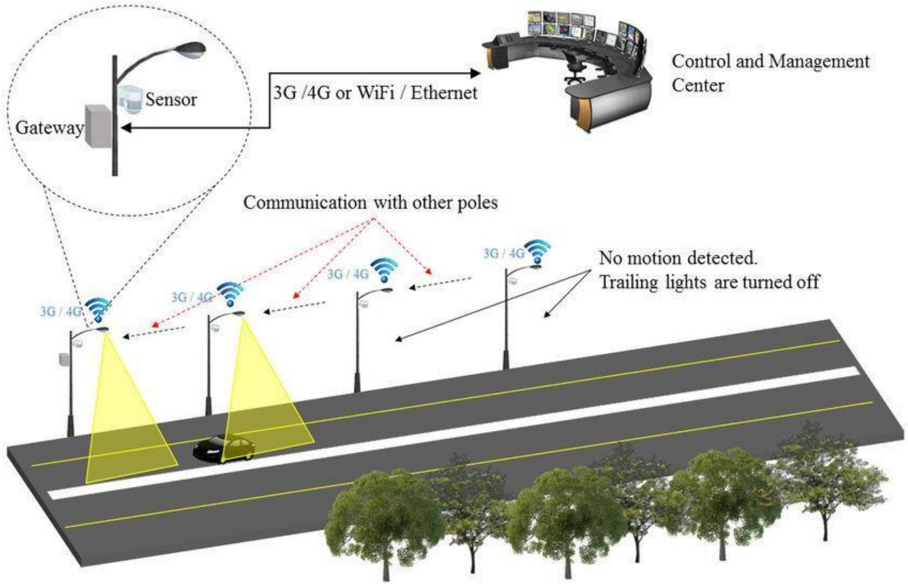

Fig 7.1 Result

8.CONCLUSION

The literature suggests that integrating sensor-based object detection with computer vision and IoT can significantly enhance the efficiency of streetlight systems. While motion sensors and adaptive lighting have been explored, real-time object classification remains an area with scope for improvement. This study aims to bridge the gap by developing an intelligent streetlight system that not only detects motion but also classifies objects for optimized lighting control, ensuring urban safety and energy efficiency.

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