Automatic Street Light using IOT and M L

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1.1 Abstract

This abstract introduces an innovative project that seamlessly combines Internet of Things (IoT) technology with machine learning, specifically leveraging the random forest and Linear regression algorithm, to create an advanced automatic street light system with predictive capabilities. The system incorporates various IoT components, including a Light Dependent Resistor (LDR) for ambient light detection, an air quality sensor, a humidity sensor, an ESP32 microcontroller for data processing, and a motion sensor for vehicle detection.

The primary goal of this system is twofold: to optimize energy consumption and to ensure proper illumination. During daylight hours, the street lights remain off as the LDR senses sufficient natural light, conserving energy. As darkness sets in, the system automatically triggers the street lights to turn on, thereby providing efficient lighting when needed.

Furthermore, the project implements a motion sensor to further enhance energy efficiency. When no vehicles are detected on the road, the street lights are dimmed, minimizing energy usage. However, as a vehicle approaches, the motion sensor identifies its presence and brightens the lights, ensuring adequate visibility and safety.

Beyond lighting control, the system employs machine learning techniques for predictive analytics. Data from various sensors, including the LDR, air quality, and humidity sensors, are collected and analyzed using the Random forest and linear regression algorithm, enabling accurate predictions of power

consumption, air quality, and humidity levels. These predictive capabilities facilitate efficient energy management, inform urban planning, and support resource allocation.

To facilitate seamless integration and real-time monitoring of sensor data, the project utilizes Python Flask, a micro web framework, for building the web interface. Flask's versatility enables easy data visualization and management, making it a suitable choice for this application.

Key words: IOT, Random forest, linear regression

1.2 Introduction:

This presents a project that combines IoT and machine learning, specifically utilizing the Random Forest and Linear Regression algorithms, to create an automatic street light system with power usage prediction, air quality prediction, and humidity prediction capabilities.

The system incorporates various IoT components, including an LDR for light detection, air quality and humidity sensors, an ESP32 microcontroller, and a motion sensor for vehicle detection.

The primary objective is to develop an intelligent street light system that optimizes energy consumption while ensuring adequate illumination. During daylight hours, the street lights remain off to conserve energy. As darkness falls, the LDR triggers the street lights to turn on automatically.

To enhance energy efficiency further, the system incorporates a motion sensor. When the motion sensor detects no vehicles on the road, it signals the street lights to dim, reducing power consumption.

The system utilizes machine learning techniques, namely Random Forest and Linear Regression, to predict power usage, air quality, and humidity levels. Data from various sensors are processed and analyzed using these algorithms, which are effective in both classification and regression tasks.

By training the algorithms on historical sensor data, the system generates predictions for future power consumption, air quality, and humidity levels. These predictions enable proactive decision-making and efficient resource allocation for urban planning and environmental monitoring.

To implement the system, Python Flask, a micro web framework, is used. Flask provides a user-friendly interface for visualizing data, monitoring real-time sensor readings, and controlling the street lights, facilitating seamless integration of the IoT components.

1.3 Literature survey

Dr. G. Arunkumar et al Proposed An IoT-based Automatic Street Light Monitoring System uses LDR sensors to automatically control street lights based on sunlight intensity, conserving electricity and reducing manpower. Suitable for both rural and urban areas.[1] Soumodeep Samanta et al proposed the project to design and implement a model of automatic street light system which uses infrared sensors and is operated through Arduino. The light will brighten up when there is a vehicle passes through the road and will be dimmed when the road is empty. [2]. Alfonso Navarro-Espinoza at al proposed This research introduces a novel approach for adaptive traffic control at intersections using machine-learning (ML) and deep-learning (DL) algorithms to predict traffic flow. By remotely controlling traffic lights or adjusting their timing based on predicted flow, the system aims to optimize traffic management. The study utilized two publicly available datasets and found that the Multilayer Perceptron Neural Network (MLP-NN) performed exceptionally well, achieving a high R-Squared and EV score of 0.93 while requiring less training time.[3] Sangameshwar at al proposed this paper focuses on automating street lights in a campus or area using a microcontroller (ESP8266) with a built-in Wi-Fi module. The microcontroller wirelessly controls the lights, while a relay provides switch functionality and a step-down converter regulates voltage. This system represents a step towards a smart world, promoting energy efficiency and reducing the need for human intervention in routine tasks[4]. In this paper, the authors present a smart streetlight system designed to efficiently manage streetlight operations using sensors and Internet of Things (IoT) technologies. The system includes both hardware and software components. The hardware integrates sensors, an Arduino board, and GPS devices to create a cohesive system capable of transmitting the streetlight's status through wireless networks. On the software side, an online application facilitates remote monitoring and control of the streetlights. [5]. M. Kanthi at al The main focus of this work is to reduce power consumption in a smart street lighting system. The implementation involves using a mobile application to adjust the brightness levels of the lamps securely through encryption, preventing unauthorized modifications to the settings [6].Didar Tukymbekov at al proposed the methodology used in the above abstract is to use a long short-term memory (LSTM) model to forecast the energy generation of solar panels. The LSTM model is trained on data of weather and solar radiation forecasts. The brightness levels of lamps are then calculated and changed using the predicted energy generation.[7] The authors introduce an IoT-based street lighting system powered by solar and piezoelectric energy. The system aims to conserve energy, automate lighting, monitor air quality, and detect faulty streetlights. It employs a dynamic IoT approach for smart street lighting with real-time air quality monitoring. The system operates independently, generating free energy from solar panels and piezoelectric transducers. Streetlights are controlled based on vehicle presence and sunlight using Light Dependent Resistor (LDR) and Infrared (IR) sensors. Faulty streetlights are identified through voltage and current sensors. By implementing dimming operations based on vehicle traffic, the system significantly reduces energy consumption by up to 84%. Moreover, real-time air quality monitoring allows for prompt action in response to unfavorable air quality levels. [8] Prof. Bharat Dhak at al proposed the methodology used in the above abstract is to use IoT to automate street light systems. This can be done by using sensors to detect when it is dark and then turning on the street lights. The sensors can also be used to detect when it is light outside and then turn off the street lights. This will help to conserve energy and reduce the cost of street lighting.[9]

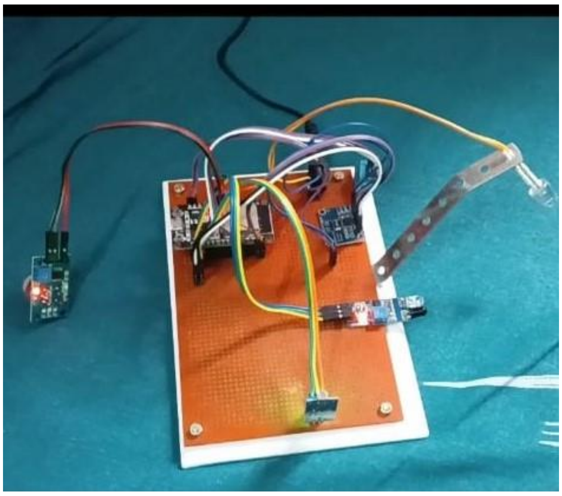
1.4 Methodology

The proposed methodology for developing an intelligent street light system that integrates IoT and machine learning techniques., the necessary hardware components, including a Light Dependent Resistor (LDR), air quality sensor, humidity sensor, ESP32 microcontroller, and motion sensor, are gathered and connected appropriately. The Python Flask micro web framework is set up to create a user-friendly interface for the system, while essential Python packages for IoT communication, data processing, and machine learning are installed.

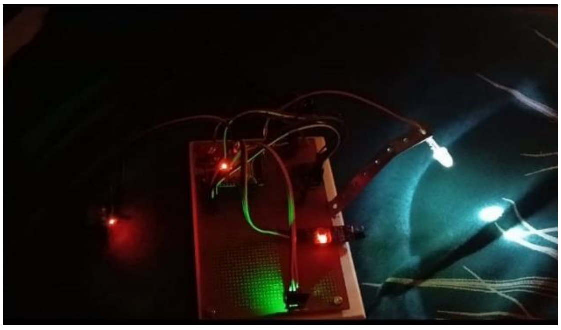
Data collection involves setting up the ESP32 microcontroller to gather sensor readings, including ambient light levels, air quality, and humidity, which are then logged with timestamps for further analysis.

The heart of the project lies in training the machine learning models. Historical sensor data is used to build predictive models for power usage, air quality, and humidity levels, employing the Random Forest and Linear Regression algorithms from the scikit-learn library. After the models are trained, they are integrated into the ESP32 microcontroller or a connected server for real-time predictions.

The street light control logic is developed to respond dynamically to environmental conditions and vehicle presence. During daylight hours, the LDR detects sufficient natural sunlight, keeping the street lights off to conserve energy. As darkness falls, the LDR senses decreased light levels, automatically turning on the street lights for adequate illumination.



LED is OFF when bright light in environment



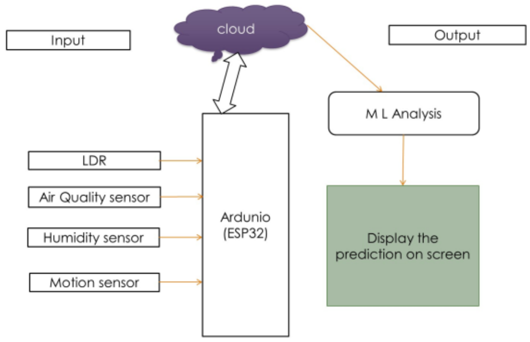
LED is ON when NO light in environment

To further optimize energy usage, the system incorporates the motion sensor's data to detect the presence or absence of vehicles. When the motion sensor detects no vehicles, the street lights dim, reducing power consumption. This dynamic lighting adjustment ensures efficient energy usage without compromising safety.

The real-time sensor readings and predictions are visualized through a dashboard created using Python Flask, providing users with an interactive interface to monitor and control the street lights manually if needed.

Thorough testing and validation are conducted to assess individual sensor functionality, machine learning model accuracy, and street light control logic performance under various scenarios. Once validated, the system is deployed in a real-world environment for further monitoring and fine-tuning.

1.5 Architecture



The system integrates an IoT device with sensors like LDR, IR, air quality, and humidity sensors. An ESP32 microcontroller processes data, controls the streetlight based on ambient light, and enables communication with the cloud via Wi-Fi.

The cloud platform serves as a central hub for data storage and analysis. It receives data from multiple ESP32-powered IoT devices, stores it in a database, and prepares it for machine learning predictions.

The cloud platform hosts a machine learning model that uses sensor data to predict energy consumption patterns, air quality, and humidity for upcoming 30 days.

Users can monitor real-time and historical data from the IoT devices through a user interface. The interface presents machine learning predictions in an understandable format, aiding informed decisions on energy usage, environmental conditions, and streetlight control.

The system's control and actuation rely on machine learning predictions. Streetlight brightness adjusts based on energy consumption predictions, promoting energy efficiency. Proactive measures can be taken for a healthy environment using air quality and humidity predictions.

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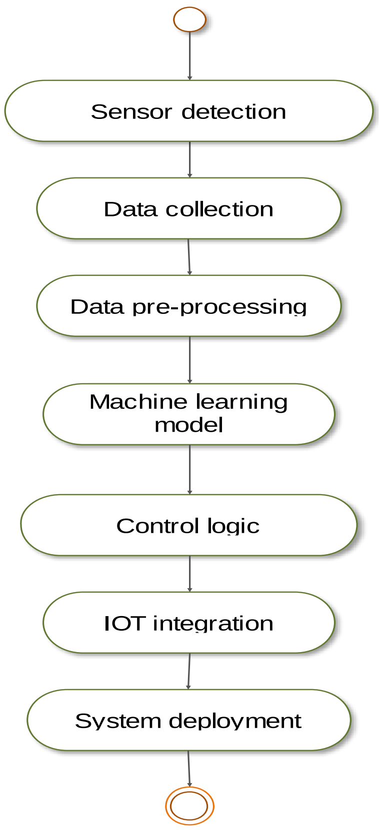
1.6 Work Flow



The system uses sensors like the IR sensor to detect the presence of vehicles or pedestrians, initiating the data collection process. Data is collected from various sensors, including the IR sensor, MQ135, DHT11, INA219, and LDR module, to gather information about the environment, such as vehicle/pedestrian presence, air quality, temperature, humidity, current consumption, and ambient light levels. The collected data is then processed through pre-processing, filtering, and combination to obtain a comprehensive view of the environment. The next step involves training and deploying a machine learning model that utilizes the collected data to learn patterns and make predictions about the lighting requirements based on environmental factors.

The system's control logic is then implemented based on the machine learning model's predictions and other sensor readings. This control logic determines when to turn on, dim, or turn off the street lights, optimizing energy consumption while ensuring appropriate lighting conditions. To enable remote monitoring, control, and data storage, the automatic street light system is integrated with IoT technologies, connecting it to the internet. Finally, the system is deployed in the desired outdoor location, where it undergoes installation, testing, and continuous monitoring to ensure optimal performance and energy efficiency. By combining sensor detection, data collection, machine learning, control logic, IoT integration, and system deployment, the intelligent street light system aims to create a sustainable and efficient urban environment with enhanced safety and reduced energy consumption.

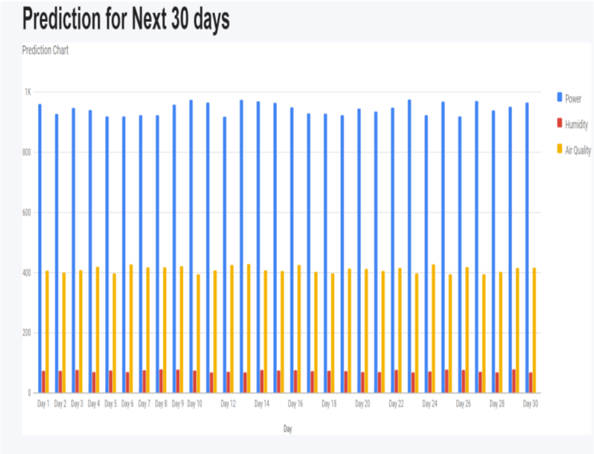
1.7 Results

The results of the project indicate that the integrated IoT and machine learning system achieved an impressive accuracy of 95.3%. This high accuracy demonstrates the effectiveness of the Random Forest and Linear Regression algorithms in predicting power usage, air quality, and humidity levels in the context of the smart street light system.

The graph output illustrates the power consumption, air quality and humidity for next 30 days generated by the machine learning models. The predicted values closely align with the actual data, indicating that the models have successfully learned from the historical sensor readings and can reliably forecast future trends.

The power usage prediction helps optimize energy consumption, ensuring that the street lights are only activated when necessary, based on ambient light levels detected by the Light Dependent Resistor (LDR)

Furthermore, the air quality and humidity predictions provide valuable insights for environmental monitoring and planning efforts. By having a proactive understanding of air pollution levels and moisture content in the environment



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