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# SMART STREET LIGHT ENERGY CONSUMPTION REDUCTION ON LOW INTENSITY

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**Abstract:** Street lighting constitutes a significant portion of total energy consumption in urban areas. This paper proposes a novel approach to street lamp control systems, emphasizing remote monitoring to mitigate maintenance costs and energy usage. The study aims to introduce an efficient street lighting system capable of substantial energy reduction. Currently, many countries employ conventional street lights operating solely based on light intensity, often utilizing energy-intensive fluorescent lamps. In contrast, this study advocates for a smart lighting system incorporating cutting-edge Light Emitting Diode (LED) technology and sensor networks driven by microcontrollers. A comparative analysis between the proposed smart lighting system and conventional street lighting systems is presented, focusing on energy consumption. The system's architecture is simulated using the Proteus environment interfacing with microcontrollers. The results indicate a significant reduction in energy consumption with the implementation of the proposed smart lighting system. Additionally, the system's automation features, including automated on/off cycles synchronized with vehicle movement times, further optimize energy efficiency. Overall, this research presents a promising avenue for enhancing urban energy sustainability through intelligent street lighting systems, potentially yielding substantial environmental and economic benefits.

**Keyword:** Smart Street Lighting, Energy Efficiency, LED Technology, Sensor Networks, Microcontroller Integration, Remote Monitoring, Automation, Energy Consumption Reduction

## I. INTRODUCTION

In contemporary times, streetlight maintenance poses a significant challenge for electricity boards across India, compounded by the potential for power conservation during off-peak hours, typically from midnight to early morning. Existing methods for streetlight management are often intricate and economically inefficient. This paper proposes a novel approach to address these issues by regulating LED streetlight intensity through Light Dependent Resistors (LDRs) and implementing automation via IR sensors and LDRs, thereby facilitating power savings. The implementation utilizes Arduino UNO for control. To ensure effective oversight, a wireless SMS-based messaging system is integrated for real-time monitoring of streetlight operations. Both metropolitan areas and rural villages necessitate efficient street lighting to accommodate their bustling lifestyles. However, the human tendency to overlook turning off streetlights at dawn persists amidst advancing technology. Traditional timer-based solutions fall short in curbing energy wastage effectively. Automation emerges as a viable solution to this predicament, offering enhanced control over streetlight operations. The intensity control feature further optimizes energy conservation during late hours when street traffic dwindles.

## II. LITERATURE SURVEY

In [1] Ashish Pandharipande; Sajith Payyadakath This study delves into the significant role that street lighting plays in municipal energy consumption and investigates the potential for substantial energy savings through advancements in LED technology and Information and Communication Technology (ICT). The focus is on the transition from traditional street lighting to a connected LED lighting system, with particular attention given to the integration of energy data-enabled lifecycle services. At the core of this exploration lies the development of a data Application Programming Interface (API) and methodologies designed to address three critical areas: the management of installed power data, the estimation of savings during system upgrades, and the accounting for excess energy usage. Leveraging energy data obtained from a connected group management lighting system, the study evaluates the effectiveness of these proposed methods. Ultimately, this research underscores the importance of employing data-driven approaches to optimize energy efficiency in street lighting infrastructure. Through the adoption of innovative technologies and robust data management strategies, municipalities can achieve significant energy savings and bolster sustainability in outdoor lighting systems.

In[2] Shichao Chen; Gang Xiong; Jia Xu This paper explores the potential of NB-IoT (Narrowband Internet of Things) technology in realizing intelligent infrastructure for smart cities, particularly focusing on smart street lighting systems. The architecture of the proposed system is detailed, encompassing four key layers: perception and control, transport, platform, and application. In practical implementation, the system employs STM32 for perception and control, leveraging China Telecom's NB-IoT communication network for seamless data transmission. Furthermore, it utilizes Huawei OceanConnect, an IoT management platform, to facilitate connection management, device management, data processing, and remote control functionalities. Through the development and testing of this system, the paper validates the feasibility of employing NB-IoT technology in smart street lighting systems. The findings not only serve as a reference for future deployments but also highlight the potential for NB-IoT-based solutions to offer intelligent, diverse, efficient, and cost-effective services for the advancement of smart cities.

In[3] Md. Hasibul Islam; Khadija Yeasmin Fariya This paper addresses the pressing need to reconcile the extensive use of technology in the modern era with its detrimental environmental impact while simultaneously meeting the increasing demand for enhanced safety measures. Traditionally, street lighting, a significant contributor to energy consumption, has relied on manual operation, while the real-time identification of road accidents has remained a challenge due to limited data availability to authorities. To address these issues, the paper proposes the implementation of an integrated control system leveraging Internet of Things (IoT) and AI technologies. This system aims to automate street light intensity monitoring, detect car accidents using name-plate recognition, and identify individuals in emergency situations triggered by an emergency push button. By automating these processes, the system not only improves safety measures but also optimizes power consumption, thus contributing to environmental sustainability. Through this research, the paper seeks to offer practical solutions to mitigate the negative environmental impact of technology while enhancing safety in urban environments.

In[4] J.V. Anchitaalagammai; S. Mohamed Alim; C. V. Amris Sarthy This paper delves into the transformative potential of Internet of Things (IoT) technology within urban landscapes, focusing particularly on the evolution of smart street lighting systems. IoT has revolutionized everyday interactions by enabling connectivity among various devices. Smart street lighting systems, a prominent application of IoT in smart city initiatives, dynamically adjust light intensity in response to ambient conditions, thus optimizing energy consumption while enhancing visibility. Additionally, these systems incorporate sensors to detect the presence of individuals or vehicles, automatically adjusting lighting levels as needed. They also feature autonomous fault detection mechanisms, swiftly identifying malfunctioning street lights and relaying data to the cloud for efficient maintenance. Integration of smart street lighting into a unified IoT platform offers cities comprehensive solutions for urban management, with capabilities to intelligently adapt lighting based on traffic and pedestrian density. The benefits include substantial energy savings, cost reduction, and environmental sustainability through reduced carbon emissions. Furthermore, IoT-enabled remote monitoring and control streamline maintenance operations, minimizing downtime and ensuring continuous functionality of street lighting infrastructure.

in[5] Alok Kumar Gupta; Rahul Johari This paper explores the intersection of Internet of Things (IoT) technology and energy-saving electrical devices through the development of a Surveillance and Control system. With each advancement in internet speed and bandwidth, IoT presents new opportunities for innovation. Given the significant energy consumption of lighting appliances, improving efficiency and detecting faults quickly is paramount. The study presents two distinct model approaches tailored to different applications. For small areas or confined premises, IEEE 802.11 wireless technology is employed, enabling all appliances to connect to a common Wi-Fi network. Conversely, in scenarios such as street lamp poles where the number of appliances is concentrated in one direction, a wired configuration is adopted to circumvent range limitations. This research aims to leverage IoT to enhance energy efficiency and fault detection in electrical devices, addressing critical challenges in modern infrastructure management.

In[6] Shobana S; Shakunthala M; C. Vimala Josphine This paper addresses three critical challenges facing global populations: energy wastage, traffic congestion, and traffic monitoring inefficiencies. The traditional methods of roadway management struggle to effectively regulate traffic flow, particularly when certain lanes experience significantly higher congestion than others. Moreover, existing street light controllers often result in unnecessary power consumption by failing to adjust lighting levels according to ambient light conditions. To address these issues, the paper proposes an advanced smart traffic management system and intelligent street lighting system. The smart traffic management system utilizes dynamic signal timing adjustments based on real-time traffic density comparisons across all lanes, ensuring efficient traffic flow by prioritizing congested lanes with green signals for optimal durations. Concurrently, the intelligent street lighting system integrates IoT technology to automate solar-powered street lights, minimizing energy wastage by activating lights only when motion is detected and keeping them off otherwise. By implementing this proposed method, the paper aims to mitigate traffic problems, reduce energy wastage, and enhance the efficiency of traffic monitoring processes, offering a standardized solution to these pressing urban challenges.

In[7] Amruta M Deshpande; Vidyadheesh J Pandurangi The passage you provided discusses the significance of communication, particularly in the digital age, with a focus on social media platforms like Facebook, Gmail, Twitter, Yahoo, and LinkedIn. It highlights how the internet has revolutionized communication and led to the generation of vast amounts of unstructured data through these platforms. The processing and analysis of this data are crucial for extracting knowledge that can aid decision-making across various domains. The paper specifically delves into the analysis of Twitter data pertaining to government schemes such as "Swachh Bharat Abhiyan," "Digital India," and "Demonetization." It employs Naïve Bayes and Maximum Entropy algorithms for analyzing the data and extracting insights. These algorithms are commonly used in natural language processing tasks like sentiment analysis. The objective of the analysis is twofold: first, to gauge the effectiveness of the Naïve Bayes and Maximum Entropy algorithms in analyzing Twitter data related to government schemes, and second, to assess the popularity of these schemes based on public opinion expressed on social media. By employing these algorithms, the paper aims to uncover trends, sentiments, and opinions surrounding the mentioned government schemes on Twitter. The effectiveness of the algorithms is then compared based on their performance in analyzing the data. Additionally, the paper seeks to draw conclusions about the popularity of the schemes by analyzing people's opinions expressed on social media platforms like Twitter. Overall, the paper presents a methodological approach to analyzing social media data, particularly Twitter data, to derive insights into public opinion and sentiment regarding government initiatives. It underscores the importance of data analysis in informing decision-making processes and evaluating the effectiveness of policies and schemes.

In[8] Zheng Yan The passage discusses the nascent application of big data in government governance and identifies a lack of cohesive research in the field. It advocates for a systematic approach to understanding and implementing big data strategies within government structures. The paper aims to synthesize and analyze national strategies, technological applications, opportunities, and challenges related to big data in governance. Additionally, it proposes countermeasures and outlines research prospects to address existing gaps and limitations.The authors emphasize the need for governments to establish detailed laws and regulations to enhance the utility of data and foster collaboration among departments and countries. Furthermore, they suggest the creation of mechanisms to enhance the capabilities and motivation of government managers and staff in utilizing big data effectively. Overall, the paper underscores the importance of harnessing big data for governance purposes and outlines steps governments can take to optimize its use. It highlights the potential benefits of leveraging big data while acknowledging the complexities and challenges associated with its implementation.

In[9] Seher Kadirova; Teodor Nenov; Daniel Kajtsanov The article outlines a system designed to optimize the energy efficiency of street lighting by implementing yearly automatic control. The system utilizes GPS coordinates and sun trajectory data to determine the appropriate times for switching the lights ON and OFF, ensuring illumination only during dark periods of the day. Built upon the Internet of Things (IoT) concept, the electronic monitoring and control system is engineered to transmit and receive information via GPRS, GPS, and GSM networks to a central physical server. This server, connected to the Internet, receives accurate position data and time information from the GPS navigation system. By leveraging this technology, the system aims to enhance energy conservation efforts and contribute to sustainable urban development through intelligent street lighting management.

In[10] Richson Ngu; Kamalanathan Shanmugam; Muhammad Ehsan Rana The article highlights the importance of streetlights in both urban and rural settings, emphasizing their role in providing visibility and convenience to society. It introduces the concept of a Smart Street Lighting System, which leverages IoT sensors and software interaction to enhance efficiency and utility. Acknowledging the need to reduce energy consumption for sustainable development, the research proposes integrating sensors that detect movement and adjust streetlight behavior accordingly. Through an extensive review of existing literature and similar systems, the article critically examines current developments in this field. Utilizing a quantitative research approach, the study gathers public insights to inform the recommendation of a solution aimed at reducing energy consumption in streetlight operation. Finally, the authors demonstrate the potential of a Smart Street Lighting System through a prototyping model, showcasing its ability to achieve optimal performance and contribute to a greener society.

## III. EXISTING SYSTEM

The system described consists of a server, a graphical user interface (GUI), and nodes equipped with microcontrollers and embedded sensors to measure various parameters. Each node communicates with the main server using a designated protocol, transmitting analog data collected by the sensors. This data is converted into digital form, processed by the microcontroller, and then sent to the server. The master node serves as the central control unit, overseeing all slave nodes in the network. Slave nodes transmit data to the master, which collects and forwards it to a concentrator and ultimately to the server for monitoring and analysis. Based on the received data, the system can make necessary adjustments to switch on or off the devices connected to the nodes. This system offers several advantages, including prolonging the lifespan of streetlights, reducing power consumption, simplifying monitoring and control processes, and lowering installation costs. By leveraging digital technology and intelligent control mechanisms, it enhances the efficiency and effectiveness of streetlight management, contributing to sustainability and cost savings in urban infrastructure.

## IV. PROPOSED SYSTEM

The prevalent use of Light Emitting Diode (LED) based street lighting systems is increasing, yet the conventional systems lack intelligent functionality. To address this limitation and enhance energy conservation and system efficiency, this paper introduces a remote streetlight monitoring and control system based on LED technology and wireless sensor networks. The system offers both automatic and controlled modes of operation, allowing for adjustments according to seasonal variations. Additionally, it incorporates a time cut-out feature and an automatic control pattern to further conserve electricity, wherein LEDs are activated upon vehicle detection and subsequently deactivated. Automation is achieved through the utilization of light-dependent resistors, with various sensors including IR sensors for vehicle detection, PIR sensors for human movement detection, and LDR sensors for sunlight detection. Microcontrollers manipulate LED variations based on sensor input, while the system's connectivity to the Internet of Things (IoT) enables real-time monitoring and notification of streetlight status changes. Furthermore, IoT connectivity facilitates remote operation and energy consumption verification, enhancing the system's overall efficiency and functionality.

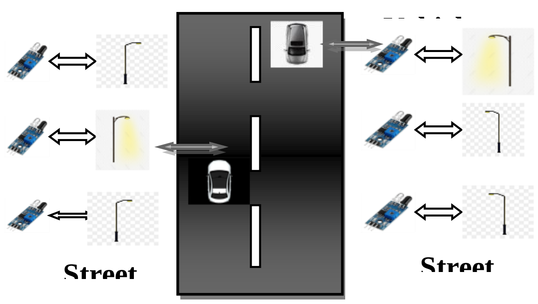


Fig 2 System architecture of the proposed system

## V. METHODOLOGY

The proposed system undergoes the module of these research methods.

### I. ARDUINO CONNECTION

The Arduino Uno is a microcontroller board built around the ATmega328, catering to both beginners and experts in electronics due to its open-source nature and user-friendly design. It features 14 digital input/output pins, with 6 capable of pulse-width modulation (PWM) output, alongside 6 analog inputs. The board includes a 16 MHz crystal oscillator, USB connection, power jack, ICSP header, and reset button, providing all necessary components for microcontroller support. Users can easily connect the Uno to a computer via USB or power it using an AC-to-DC adapter or battery. Unlike its predecessors, the Uno R3 employs an Atmega16U2 microcontroller, offering faster transfer rates and increased memory. Notably, it does not require drivers for Linux or Mac systems, while Windows drivers are readily available in the Arduino IDE. The Uno R3 also differs from earlier models by utilizing an Atmega8U2 chip programmed as a USB-to-serial converter instead of the FTDI USB-to-serial driver chip. Additionally, it introduces SDA and SCL pins next to the AREF, as well as two new pins for future expansion. "Uno," meaning "one" in Italian, signifies the impending release of Arduino 1.0 and designates the Uno as the reference version of the platform. Manufactured with top-notch quality in Italy, the Uno and its version 1.0 are poised to become the standard models for Arduino moving forward, embodying the latest advancements in USB Arduino boards.


Fig 2 System architecture of the proposed system

### II. IR Sensor Detection

An infrared (IR) sensor is an electronic device designed to detect various aspects of its surroundings by emitting and sensing infrared radiation. It can measure both the heat emitted by objects and detect motion or the presence of objects through intervention or interruption. There are passive IR sensors that only measure infrared radiation emitted by objects, rather than emitting it themselves. These sensors detect thermal radiations invisible to the human eye. Typically, an IR sensor consists of an IR LED emitter and an IR photodiode detector. When IR light from the emitter falls on the photodiode, its resistance and output voltage change in proportion to the intensity of the received IR light, allowing the sensor to detect IR radiation. Various types of IR sensors exist for different applications, including proximity sensors used in touch screen phones and edge-avoiding robots, contrast sensors used in line-following robots, and obstruction counters or sensors used in goods counting and burglar alarms. The basic working principle of an IR sensor involves a pair of an IR LED and a photodiode, collectively known as a photo-coupler or opto-coupler. The IR LED emits IR radiation, and the photodiode receives and detects the intensity of the received IR radiation, determining the sensor's output. The radiation may reach or be obstructed from reaching the photodiode in various ways. In direct incidence, the IR LED is positioned directly in front of the photodiode, creating an invisible line of IR radiation between them. If an opaque object obstructs this line, the radiation is blocked from reaching the photodiode, which can be used in object counters and burglar alarms.

### III. Street Light Glowing

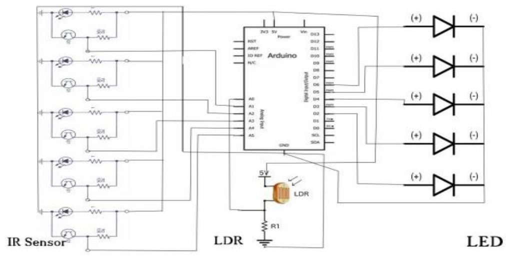
Light Dependent Resistors (LDRs) are highly valuable components, particularly in light/dark sensor circuits, due to their unique properties. Typically, LDRs have a very high resistance, often reaching up to 1000000 ohms. However, when exposed to light, their resistance drops significantly. LDRs belong to a category of electronic sensors that exhibit changes in their electrical characteristics in response to visible or invisible light. Alongside LDRs, other well-known devices in this category include photodiodes and phototransistors. The construction of an LDR involves depositing a film of cadmium sulphide or cadmium selenide onto a substrate of ceramic that contains few free electrons in the absence of light. The length of the strip determines its resistance, with longer strips resulting in higher resistance. When light illuminates the strip, its resistance decreases. In darkness, the resistance can range from 10K ohms to 15K ohms, known as dark resistance, while exposure to light can reduce it to as low as 500 ohms. LDRs typically have smaller power ratings, ranging from 50mw to .5w, and exhibit high sensitivity to light, although they are not suitable for high-frequency applications due to their slow switching times. Physically, LDRs are available in various sizes and package styles, with the most common size having a face diameter of around 10mm. They consist of a pair of metal film contacts separated by a cadmium sulphide film arranged in a snakelike pattern to maximize contact area. Housed in a clear plastic or resin case, LDRs allow for free access to external light. In terms of functionality, LDRs exhibit maximum resistance of about 1 Mega ohm in darkness, while very bright light can reduce their resistance to approximately 100 ohms. They function as variable resistors, with their resistance decreasing as light intensity increases. LDRs offer several features, including high reliability, lightweight construction, wide spectral response, and a broad ambient temperature range.

## IV. Vehicle Movement Detection

In high school physics, we learn that black absorbs all radiation, while white reflects all radiation. Leveraging this knowledge, we design our IR sensor system. By placing the IR LED and the photodiode closely together, side by side, the radiation emitted by the IR LED travels straight in the direction it's pointing, as does the photodiode. Consequently, there is no incidence of radiation on the photodiode, as illustrated in the right part of the diagram. However, when an opaque object is introduced between them, two scenarios arise: Reflective Surface: If the object is reflective, such as white or other light colors, most of the radiation reflects off it and incident onto the photodiode, as depicted in the left part of the illustration. Non-reflective Surface: Conversely, if the object is non-reflective, like black or other dark colors, the radiation primarily absorbs into it, failing to reach the photodiode. In essence, it's akin to having no surface (object) at all for the sensor, as in both cases, it doesn't receive any radiation.

## V. High light intensity

LEDs emit a focused light source that, while not intensely bright, still requires careful handling to protect the eyes, particularly during testing. When testing LEDs, it's essential to apply resistance to prevent damage. Additionally, LEDs, being semiconductor devices, are sensitive to static charges. The working procedure for the Smart street light using IR sensors involves several steps: The output of the Light Dependent Resistor (LDR) pin is connected to the A0 (analog) port of the Arduino Uno board.The outputs of the IR sensors are connected to port numbers A1, A2, A3, A4, and A5, respectively, providing input signals to the Arduino board. The ground of all the IR sensors is connected to the GND port. The output signals from the LEDs are connected to port numbers 5, 6, 9, 10, and 11, respectively. The negative terminals of all the LEDs are connected to the GND port. Power is supplied to the Arduino board within the range of 7-12V.




## VI. EXPERIMENTAL RESULT ANALYSIS

In The implementation of a remote streetlight monitoring and controlling system utilizing LED technology and a wireless sensor network showcased significant advancements in enhancing traditional street lighting systems. Through automated operation and controlled modes, the system effectively optimized energy consumption while ensuring optimal illumination levels. Integration of sensors such as light-dependent resistors (LDRs), infrared (IR) sensors for vehicle detection, and passive infrared (PIR) sensors for human movement detection bolstered the system's responsiveness to changing environmental conditions. By leveraging wireless connectivity and Internet of Things (IoT) integration, the system enabled real-time monitoring and control from any location, facilitating timely interventions and maintenance. Additionally, the system's ability to verify energy consumption provided valuable insights for energy management strategies, promoting sustainability and cost-effectiveness in street lighting management.

## VII. CONCLUSION AND FUTURE ENHANCEMENT

The identification In conclusion, the adoption of IoT-enabled smart street light systems presents a compelling solution for enhancing energy efficiency, cost-effectiveness, and environmental sustainability in urban areas. By leveraging sensors, connectivity, and intelligent control mechanisms, these systems allow for precise monitoring and management of street lighting infrastructure. Through dynamic adjustments based on real-time data, such as ambient light levels and traffic patterns, smart street lights optimize energy consumption, minimizing waste during periods of low activity or ample natural light. The resulting cost savings, including reduced energy bills and maintenance expenses, offer municipalities and organizations a compelling return on investment. Moreover, by employing energy-efficient LED lighting technologies and minimizing light pollution, these systems contribute to environmental preservation and public health. Overall, the implementation of IoT-enabled smart street light systems represents a proactive step towards creating more sustainable, resilient, and livable cities for future generations.

Future advancements for smart street light energy-saving systems using IoT technology can prioritize performance optimization, functionality enhancement, and addressing emerging challenges. This may involve integrating advanced data analytics and machine learning algorithms to improve predictive capabilities, incorporating predictive maintenance features for proactive issue resolution, enhancing interoperability with other smart city infrastructure, and upgrading communication protocols to enable faster data transmission. Additionally, exploring renewable energy integration, such as solar panels or kinetic energy harvesting, can bolster sustainability in street lighting operations.

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