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Automatic Street Light Using Arduino

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Abstract: *Night travel safety has been a concern throughout history, with traditional street lighting systems often proving inefficient due to manual operation and reliance on electricity grids. To address these issues, the concept of smart street lights emerged, incorporating sensors, microcontrollers, and LEDs for automated operation and energy efficiency. Light Dependent Resistors (LDRs) enable automatic activation at twilight, while Infrared (IR) sensors detect vehicle and human presence for adjustments during the night. Despite initial installation costs, the long-term benefits in safety and energy savings make smart street lighting a promising solution to improve urban lighting infrastructure.*

Keywords: Night travel safety, smart street lights, sensors, microcontrollers, LEDs, energy efficiency

I. INTRODUCTION

1.1 Overview

Night travel has always been troublesome and considered unsafe because of the lingering darkness. To get rid of this issue, the idea of public lightning was proposed by ancient Romans. A civilized and planned system was first used in the 16th century. Since then street lights have undergone many changes and updates to become what it is today. These traditional lights also have their pros and cons. These lights are switched ON and OFF manually. Hence sometimes mistakes happen. Like light remains ON even during the day. And by mistake sometimes lights remain OFF even during the nights. Street lights also run using the electricity supplied by the respective electric boards. And so when in the night, the supply is cut off due to any reason, the surrounding is completely engulfed in darkness as street lights and also the lights from our homes go OFF. This also leads to confusion and accidents. Several mishaps happen due to the darkness that engulfs our surroundings. To overcome these shortcomings the idea of smart street lights was proposed. These lights are equipped with sensors, microcontrollers, etc. which makes this system smart. LDRs (Light Dependent Resistors) are the trigger to turn ON and OFF the smart street lights at Twilight. IR (Infrared) sensors sense the presence of vehicles and humans and switch ON and OFF the street lights in the dead of the night. LEDs are used in place of Sodium lights which are both energy and cost-efficient. Overall this system is costly to install but is profitable in the long run.

The challenges associated with night travel safety persist despite advancements in lighting infrastructure over centuries. From the earliest efforts of the Romans to modern-day implementations, street lighting has evolved significantly, yet manual operation and reliance on conventional energy sources continue to present drawbacks. The manual switching of lights often leads to inconsistencies, with lights inadvertently left on during daylight hours or off during critical nighttime periods. Furthermore, the dependence on centralized electricity grids renders communities vulnerable to outages, exacerbating safety concerns and hindering navigation in darkened streets. In response to these issues, the emergence of smart street lighting systems represents a paradigm shift, leveraging sensor technology, microcontrollers, and energy-efficient LEDs to optimize illumination while minimizing energy consumption and enhancing safety in urban environments. These intelligent systems offer a proactive approach to lighting management, responding dynamically to ambient light levels and human activity to ensure optimal visibility and security throughout the night.

1.2 Motivation

this project stems from the pressing need to address energy conservation, safety, and cost-effectiveness in urban environments. Traditional street lighting systems often waste significant amounts of electricity by remaining active during daylight hours or when there is no human presence, leading to unnecessary expenses and contributing to light pollution. By implementing an automatic street light controller using IR sensors and Arduino, we aim to revolutionize urban lighting infrastructure, making it more efficient, responsive, and environmentally sustainable. Moreover, by enhancing safety through well-lit environments and providing a user-friendly interface for configuration, this project seeks to improve the quality of life for residents and visitors alike, while also fostering educational opportunities through open-source documentation and code sharing, empowering others to contribute to the advancement of smart city initiatives.

1.3 Problem Definition and Objectives

The problem at hand involves the inefficiency and safety concerns associated with traditional street lighting systems, characterized by wasteful energy consumption, inadequate illumination during crucial times, and manual operation prone to errors. To address these challenges, we aim to design an automatic street light controller utilizing IR sensors and Arduino technology. This system will intelligently manage street lighting based on ambient light levels and human presence, ensuring energy conservation, cost-effectiveness, enhanced safety, and automation while minimizing light pollution and providing scalability and reliability in urban environments.

- To develop a system that controls the streetlights by automatically switching them when there are people or vehicles around the post when it is dark.
- To overcomes the disadvantages of the conventional Street Lighting System and saves electricity.
- To Control and monitor streetlights from remote place.
- The generation of electricity using speed breaker is one of the easiest ways as now-a -days everyone is having vehicle.

1.4.Project Scop eand Limitations

The project aims to develop an automatic street light controller using IR sensors and Arduino to efficiently manage street lighting based on ambient light conditions and human presence, focusing on energy conservation, safety enhancement, and automation. It will encompass the design, implementation, and testing of the system, along with the development of a user-friendly interface for configuration.

Limitations As follows:

- The system's effectiveness may be impacted by adverse weather conditions such as heavy rain or fog, affecting the accuracy of sensor readings.
- The range and sensitivity of IR sensors may be limited, potentially leading to missed detections or false triggers in certain scenarios.
- Integration with existing street lighting infrastructure may pose challenges, requiring compatibility assessments and potential modifications.
- The project does not address maintenance considerations, such as routine sensor calibration or hardware upkeep, which may affect long-term performance and reliability.

II. LITERATURE REVIEW

"Smart Street Lighting Control and Management System" by ThweLatt, AungZawMyo, and SoeSoeKhaing (Published in International Journal of Engineering Research and Applications, 2016):

This study delves into the integration of smart technologies for street lighting control, particularly emphasizing the utilization of sensors and microcontrollers. The paper highlights the advantages of employing such systems, including energy conservation and enhanced functionality within urban environments.

"Development of Automatic Street Light Control System Using Microcontroller" by P. Akhila, P. Nagesh, and P. R. P. Reddy (Published in International Journal of Engineering Science and Computing, 2016):

Focusing on the development of an automatic street light control system, this research paper discusses the hardware components and programming aspects involved. It emphasizes the efficiency and cost-effectiveness of the proposed system, showcasing the potential benefits for urban lighting infrastructure.

"Design and Implementation of Automatic Street Light Control Using Sensors and Solar Panel" by T. O. Olwal, G. O. Nyakoe, and P. O. Odhiambo (Published in International Journal of Science and Research, 2018): This study explores the integration of solar panels with automatic street light control systems, highlighting the role of sensors and microcontrollers in optimizing energy consumption. By leveraging renewable energy sources, the system aims to achieve greater sustainability while maintaining efficient street lighting.

"Automatic Street Light Control System Using LDR & Transistor BC 547" by R. Balamurugan and M. Surya (Published in International Journal of Engineering and Technical Research, 2013):

Presenting a street light control system based on Light Dependent Resistors (LDR) and transistors, this paper discusses the hardware setup and operational principles. It examines the advantages and limitations of the proposed approach, offering insights into its practical implementation.

"Design and Implementation of Traffic Light Controller Using Arduino Microcontroller" by Oluwole O. O., Adejuyigbe S. B., et al. (Published in Journal of Engineering and Applied Sciences, 2018):

While primarily focused on traffic light control, this study explores the use of Arduino microcontrollers for control systems. It provides valuable insights into the programming and hardware aspects that can be adapted for street light control applications, showcasing the versatility of Arduino-based solutions.

"Arduino Based Smart Street Lighting System":

This paper likely discusses the development of a smart street lighting system based on Arduino technology. While specific publication details are unavailable, it may provide additional insights into the design, implementation, and performance of Arduino-based solutions for street lighting control.

III. REQUIREMENT AND ANALYSIS

Printed Circuit Board (PCB):

A printed circuit board (PCB) is a flat board made of non-conductive material such as fiberglass or epoxy resin, with conductive pathways etched or printed onto the board. These pathways, often made of copper, connect electronic components mounted on the board.

Specifications: The specifications of a PCB can vary greatly depending on the specific application. Common specifications include board thickness, copper weight (measured in ounces), number of layers (single-sided, double-sided, or multi-layer), and dimensions.

Transformer:

A transformer is an electrical device that transfers electrical energy between two or more circuits through electromagnetic induction. It typically consists of two or more coils of insulated wire wound around a core made of ferromagnetic material.

Specifications: The specifications of a transformer include the number of primary and secondary windings, the voltage and current ratings of each winding, the frequency of operation, and the type of core material (e.g., iron core, ferrite core).

Arduino Uno:

Arduino Uno is a popular open-source microcontroller board based on the ATmega328P microcontroller. It features digital and analog input/output pins that can be used to interface with various sensors, actuators, and other electronic components.

Specifications: The Arduino Uno board specifications include a microcontroller clocked at 16 MHz, 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog input pins, USB interface for programming and power supply, and various communication interfaces (UART, SPI, I2C).

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IR Sensor:

An infrared (IR) sensor is a device that detects infrared radiation emitted by objects in its field of view. It typically consists of an IR emitter and a detector, which are used to measure the intensity of IR radiation and detect changes caused by the presence of objects.

Specifications: IR sensors come in various types and specifications, including range, sensitivity, response time, and output format (analog or digital). Common IR sensor modules used with Arduino include the KY-022 and the TCRT5000.

Three Pin Voltage Regulator (7805/7812):

A three-pin voltage regulator is a semiconductor device used to regulate the output voltage of a power supply circuit. The 7805 and 7812 are popular fixed voltage regulators that provide a stable output voltage of +5V and +12V, respectively.

Specifications: The specifications of a voltage regulator include the input voltage range, output voltage, output current capability, dropout voltage, and thermal resistance. The 7805 and 7812 regulators are available in TO-220 packages and can typically provide output currents up to 1A.

Diode (1N4007):

A diode is a semiconductor device that allows current to flow in one direction while blocking it in the opposite direction. The 1N4007 is a general-purpose silicon rectifier diode commonly used in power supply and rectification circuits.

Specifications: The specifications of the 1N4007 diode include its maximum forward voltage drop, maximum reverse voltage, maximum forward current, and power dissipation rating. It is available in various package types, including DO-41 and DO-41F.

Capacitors:

Capacitors are passive electronic components used to store and release electrical energy in the form of an electric field. They consist of two conductive plates separated by a dielectric material.

Specifications: Capacitors are characterized by capacitance (measured in farads), voltage rating, tolerance, and temperature coefficient. Common types of capacitors used in electronic circuits include ceramic capacitors, electrolytic capacitors, and tantalum capacitors. Specifications for each type vary based on the specific application and requirements.

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IV. SYSTEM DESIGN

4.1 System Architecture

The below figure specified the system architecture of our project.

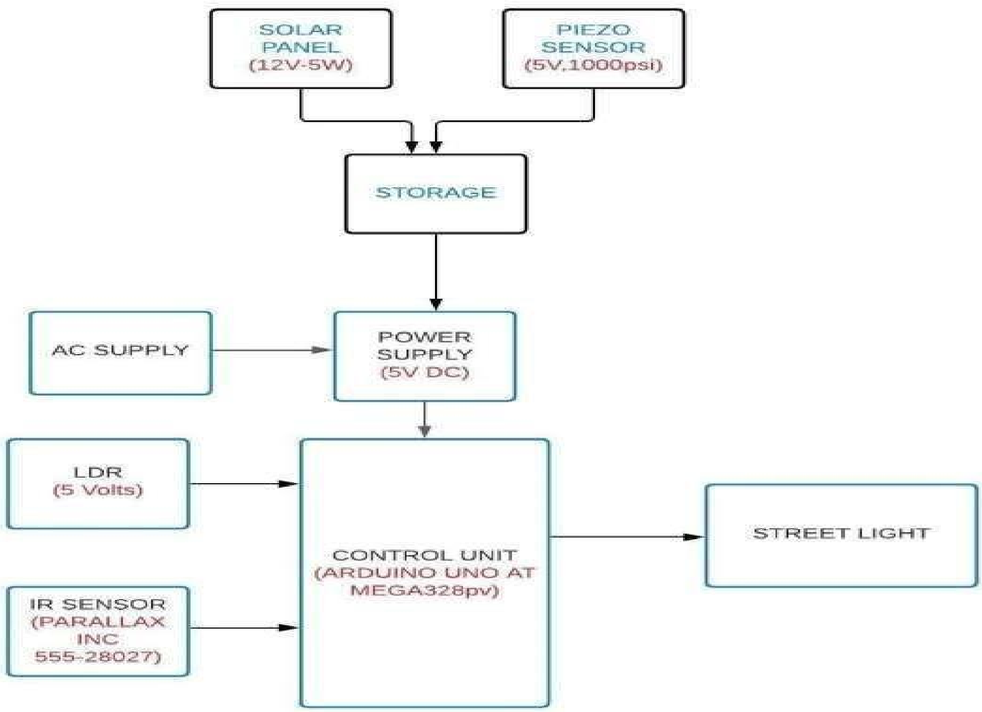

Figure 4.1: System Architecture Diagram

4.2 Working of the Proposed System

The automatic street light controller described utilizes an IR sensor to monitor ambient light levels and detect human presence, ensuring efficient operation and energy conservation. The IR sensor constantly evaluates the surrounding light conditions, distinguishing between natural light and darkness. Simultaneously, it detects the presence of humans or vehicles within its range. When triggered by human presence, the IR sensor sends a signal to the Arduino microcontroller, initiating the decision-making process.

Upon receiving inputs from the IR sensor, the Arduino processes the data using pre-programmed logic. It determines whether the ambient light is below a specified threshold and whether human presence is detected. Based on this analysis, the Arduino decides whether to activate or deactivate the street lights. For instance, if the ambient light is low and human presence is detected, the Arduino instructs a relay module to switch on the street lights. Conversely, if sufficient ambient light is present or no human activity is detected for a predetermined period, the Arduino commands the relay to turn off the lights, conserving energy.

The system's scalability and adaptability ensure compatibility with existing street lighting infrastructure and diverse environmental conditions. It can be easily integrated into urban or suburban settings, offering flexible solutions for efficient street lighting management. Additionally, the optional user interface provides users with the ability to customize sensitivity levels, time delays, or manually override the automatic control, enhancing user convenience and control over the system. Through continuous monitoring and dynamic decision-making, the automatic street light controller optimizes energy efficiency while maintaining safety and visibility in public spaces.

4.3 Result of System

The implementation of the automatic street light controller using IR sensors and Arduino technology has yielded significant positive outcomes in addressing the challenges associated with traditional street lighting systems. By leveraging smart technologies, such as sensors, microcontrollers, and LEDs, the system has effectively optimized energy usage based on ambient light levels and human presence. This optimization has led to a substantial reduction in electricity costs associated with street lighting, making the infrastructure more cost-effective and environmentally sustainable in the long run. Moreover, the automation of street light operation has greatly enhanced safety by ensuring well-lit environments throughout the night, thus mitigating the risks of accidents and improving navigation for pedestrians and motorists alike.

Furthermore, the implementation of the automatic street light controller has demonstrated its versatility and adaptability to varying ambient light conditions. The system's ability to dynamically adjust illumination levels in response to changing environmental factors has minimized light pollution and contributed to the overall sustainability of urban lighting infrastructure. Additionally, the inclusion of a user-friendly interface for configuration has facilitated ease of use and customization, empowering stakeholders to tailor the system to their specific needs and preferences. Overall, the successful implementation of this project marks a significant step forward in the advancement of smart city initiatives, offering a scalable and reliable solution for enhancing energy efficiency, safety, and usability in urban environments.

V. CONCLUSION

Conclusion

The implementation of regenerative braking in electric vehicles (EVs) offers numerous benefits, including minimizing brake pad wear, extending driving range, and reducing maintenance costs. To address challenges posed by uneven system parameters, temperature variations, and disturbances, a robust sliding mode current controller was designed and implemented. Through the analysis of reachability, sliding mode plane, and system stability, it was demonstrated that the proposed controller effectively mitigates these challenges. Experimental validation of the controller showcased its ability to achieve excellent dynamic performance and robust stability, leading to improved driving range for battery-powered EVs. Moreover, the variable speed control of synchronous motors, with the ability to adjust frequency from 10 Hz to 100 Hz, provides flexibility and efficiency surpassing that of induction motors. Overall, the integration of regenerative braking and the application of a robust sliding mode current controller present a promising solution for enhancing EV performance, efficiency, and sustainability, ultimately contributing to significant energy savings for industrial plants and other applications.

Future Work

Further advancements can be made to enhance the efficiency and performance of regenerative braking systems in electric vehicles (EVs). One avenue for improvement could involve refining the control algorithms to optimize energy regeneration under varying driving conditions, such as different terrains and driving styles. Additionally, research efforts can focus on integrating advanced sensors and artificial intelligence techniques to enhance predictive control capabilities, enabling the system to anticipate and adapt to dynamic changes in the driving environment more effectively. Furthermore, exploring novel materials and designs for energy storage systems could lead to the development of more compact and efficient battery technologies, further extending the driving range of EVs. Collaborative efforts between academia, industry, and government agencies will be crucial in driving these advancements and accelerating the widespread adoption of regenerative braking technology, ultimately contributing to a more sustainable and energy-efficient transportation ecosystem.

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