International Journal of Engineering, Management, Humanities and Social Sciences Paradigms (IJEMHS)
Volume 34, Issue 03 and Publication Date: 23rd September, 2022
An Indexed, Referred and Peer Reviewed Journal ISSN (Online): 2347-601X
www.ijemhs.com

Automatic Street Light Control Based on Ambient Light Sensing

Saradiya Kishore Parija[1], Saumendra Behera[2], Subrat Kumar Panda[3]

[1,2,3]Department of Electronics and Communication Engineering, GIFT Autonomous, Bhubaneswar, Odisha, India

Abstract: - ***The primary objective of this paper is to prevent unnecessary electricity consumption by utilizing IoT technology for street lighting systems. In today's fast-paced world, people are often too busy to turn off lights when they are not needed. This system is designed to automatically control street lights by switching them on at dusk and turning them off the next morning when there is sufficient daylight. This paper proposes an efficient solution to minimize energy wastage and eliminates the need for manual operation of street lights. The system uses two ultrasonic sensors to detect movement on the streets, while the ATmega328P microcontroller serves as the control unit for the streetlight system. The software for the microcontroller is developed using the C programming language. Ultimately, a functional prototype of this system has been successfully designed and implemented as part of the project.***

Keywords: LED lighting, Ultrasonic sensor, Ambient light sensor, Arduino board, Breadboard, Jumper wires

I INTRODUCTION

Automated systems are increasingly preferred over manual methods as they help reduce energy consumption and prevent wastage. These automation systems are integral in making everyday life more convenient, from ceiling fans to washing machines, and they have diverse applications. Street lighting, in particular, plays a crucial role in providing security and illumination during nighttime, but it also represents a significant energy cost when left on unnecessarily. Continuous lighting results in energy wastage and the overuse of electrical equipment, such as bulbs. In urban areas, street lights consume considerable power, and this inefficiency is a major concern. Traditional street lighting systems often only have two states: ON and OFF, which causes power loss as the lights run at maximum voltage at all times. This results in significant energy wastage. By integrating automation, street lighting systems can be more energy-efficient and cost-effective. The proposed system in this paper aims to use ultrasonic sensors controlled by an Arduino to optimize street lighting and reduce power consumption. Previous research has focused on street lights controlled by LDR sensors or passive infrared receivers, typically based on timers or analog circuits. Some systems use sun-tracking sensors to turn off lights when sunlight is detected. In contrast, the proposed system suggests an alternative approach, where lights dim during off-peak hours or turn on when motion is detected, saving energy while maintaining functionality. Additionally, our system can track the number of vehicles passing by, adjust the street lights accordingly, and even control security gates to prevent criminal activities. The goal is to develop a smart street light system that adjusts to environmental lighting conditions, turning off lights when no motion is detected or when daylight is present, and keeping lights dim or on when needed. This system aims to replace manual lighting systems with an efficient, automated solution, leveraging components like Arduino Uno and ultrasonic sensors.

II LITERATURE SURVEY

In many studies, street lighting systems have relied on sensors like LDR or infrared (IR) sensors to detect light levels or motion. However, these sensors often consume additional power, especially when the system is in standby mode. To overcome this issue, our approach utilizes ultrasonic sensors, which consume less power and only activate when motion is detected. Additionally, the system incorporates LED lights, which are energy-efficient and contribute to further power savings. This design ensures that energy consumption is minimized, and lights are only activated when necessary, making it a more sustainable solution compared to traditional systems.

III. PROPOSED SYSTEM

In our proposed system, the Automatic Street Lighting System will function based on the presence of vehicles or objects. The idea is that when no vehicle or object is detected on the road, the street lights will dim, reducing electricity consumption. This is in contrast to previous methods where Light Dependent Resistor (LDR) sensors were used to keep the lights on continuously. Instead, our system utilizes an

Ultrasonic Sensor to detect the presence of vehicles or objects, turning the lights on when motion is detected nearby. Thus, the system responds dynamically to motion, ensuring that the lights remain on only when necessary, saving power in the process.

3.1 Internet of Things (IoT)

The Internet of Things (IoT) refers to a network of devices connected through the internet, which can be controlled and monitored remotely. In this context, IoT utilizes various sensors and programming techniques to create systems that can autonomously monitor and manage resources. The primary goal of the IoT is to help conserve resources, reduce waste, and improve the efficiency of systems. Our system will utilize IoT techniques to save electricity and enhance the performance of street lighting by integrating sensors and controllers.

3.1.1 Arduino

Arduino Uno is the microcontroller platform that forms the core of our system. The Arduino Uno uses the ATmega328 microcontroller and provides 20 digital I/O pins, 6 of which can serve as PWM outputs, and 6 as analog inputs. It features a 16 MHz resonator, USB connection, and other components like a power jack, ICSP header, and reset button. Arduino is an open-source electronics platform designed for easy prototyping and development. It allows users to create interactive systems by reading input (like a sensor or button) and generating output (like activating a motor or lighting an LED).

Arduino is highly affordable and accessible, making it ideal for students, hobbyists, and professionals working on projects involving electronics, robotics, and IoT applications. The Arduino software (IDE) supports multiple platforms, including Windows, macOS, and Linux. It is known for its simplicity and flexibility, making it suitable for both beginners and advanced users. With a vast global community, Arduino has become an integral tool for rapid prototyping and has been used in various IoT applications, including wearable tech, 3D printing, and embedded systems.

3.1.2 Ultrasonic Sensor

The Ultrasonic Sensor is used to detect obstacles or objects by emitting ultrasonic waves. These sensors measure the distance to an object by calculating the time it takes for the emitted wave to reflect back after hitting an object. The ultrasonic sensor is ideal for non-contact detection of presence, distance, position, and level.

Ultrasonic sensors have a wide range of applications, including:

- Distance measuring: Accurate distance calculations based on the time-of-flight of sound waves.
- Proximity sensing: Detecting the presence of nearby objects.
- Collision avoidance: Used in robots and autonomous vehicles for obstacle detection.

One of the advantages of ultrasonic sensors over infrared sensors is that they are not affected by factors like smoke, dust, or color. Their ability to detect objects across a wide range of surfaces makes them reliable in various environments, both indoors and outdoors.

3.1.3 LED

A Light Emitting Diode (LED) is a semiconductor device that emits light when an electrical current flows through it. The LED operates through a process of electroluminescence, where electrons recombine with holes in the semiconductor material, releasing energy in the form of light.

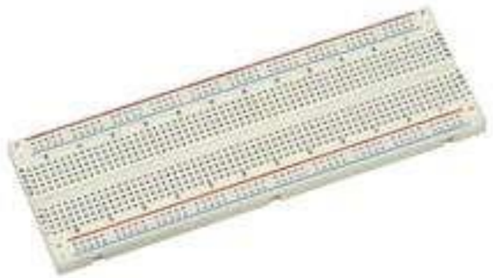
LEDs are widely used in street lighting due to their energy efficiency, long lifespan, and low maintenance. They provide a focused and bright light, making them ideal for street lighting applications.

3.1.4 Jumper Wires

Jumper Wires are used to make temporary connections between two points in a circuit without the need for soldering. These wires are commonly used in breadboards for prototyping and testing circuits. Jumper wires come in various forms, such as solid tips for breadboards, crocodile clips for temporary connections, and banana connectors for DC and low-frequency AC signals.

3.1.5 Breadboard

A Breadboard is a tool for building and testing electronic circuits without soldering. It allows for easy connection of components and facilitates prototyping. Breadboards have metal strips inside them, which interconnect the terminals of electronic components, allowing for the construction of a circuit without permanent connections. This is particularly useful for developing and testing circuits in the early stages of design.



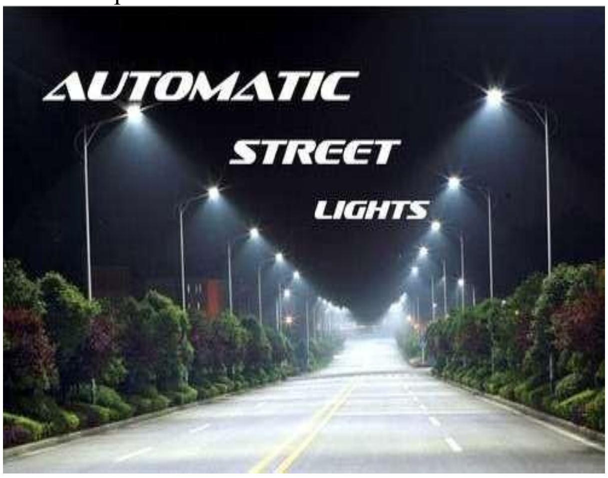
IV. PROJECT METHODOLOGY

(i) **ARDUINO IDE**: The Arduino Integrated Development Environment (IDE) is open-source software that simplifies the process of coding and uploading programs to the Arduino board. It is compatible with multiple operating systems, including Windows, MAC OS, and Linux. The software is written in Java, so the Java runtime must be installed on the machine to run the IDE. It is commonly used with any Arduino board.

(ii) **OrCAD**: OrCAD provides a comprehensive solution for schematic design and PCB layout. The Capture program includes a project wizard, offering an easy way to create projects along with the necessary libraries and simulation resources.

V.FEATURES

The intelligent street lighting system utilizes inputs from ultrasonic sensors connected to the microcontroller. The Arduino microcontroller manages the streetlights through an embedded system. A printed circuit board (ZERO PCB) is used to implement the entire circuit.



VI.SCOPE

With some modifications, the proposed model can be implemented on a larger scale with added functionalities. Some potential improvements include:

- The system could notify the public about passing emergency vehicles like fire trucks or ambulances by installing different colored LEDs on the streetlights. When the vehicle approaches, a signal would be sent to the microcontroller to turn on the corresponding LED, alerting the public.
- The ultrasonic sensor could also measure the density of vehicles on the road, informing the public about traffic levels and advising on the best routes. A large LCD screen could display this information.

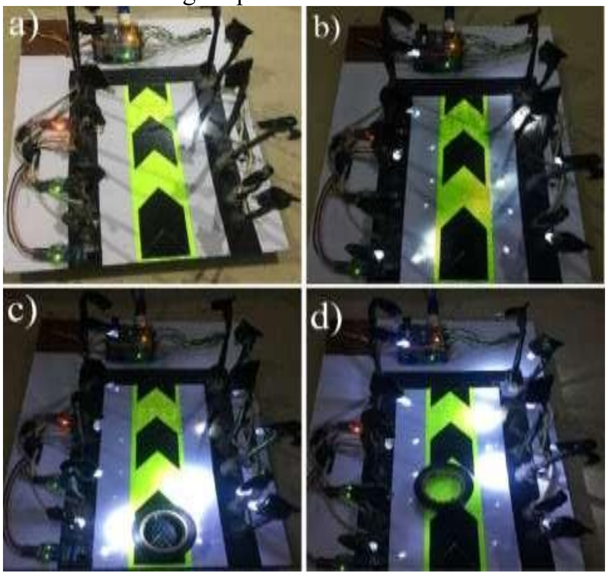
VII. RESULTS AND DISCUSSION

Initially, the ultrasonic sensor detects the ambient light intensity and sends the data to the Arduino. The Arduino converts the data (ranging from 0, representing maximum darkness, to 1023, indicating maximum brightness) and adjusts the output voltage accordingly, ranging from 0 to 2.5V/5V (DIM/HIGH). The threshold value, chosen randomly by the user (in this case, set to 10), determines whether the LEDs are in a DIM state (at night) or fully bright (during the day).

The IR obstacle avoidance sensor works by detecting objects. When an object blocks the sensor, the microcontroller interprets the signal as motion and changes the LED status. The LEDs will progressively turn from DIM to HIGH as objects pass through each IR sensor. This functionality continues for all IR sensors, and the LEDs dim or brighten based on the detected motion. The proposed system efficiently controls the streetlights based on both light intensity and object detection.

Result Diagrams:

- (a) During a day/night simulation, the LEDs remain off.
- (b) Object detected by the first IR sensor: LEDs glow at HIGH intensity.
- (c) Motion detected by the third IR sensor: corresponding LEDs glow at HIGH intensity.
- (d) Object detected by a door sensor: the door opens automatically, and the relevant LEDs light up.



VIII. CONCLUSION

This project has significant real-world potential if implemented by governments. The intelligent streetlight system can save substantial energy by replacing sodium vapor lamps with LEDs and automating the control of streetlights to prevent unnecessary electricity usage. The system is eco-friendly, cost-effective, and a safer way to manage streetlights. The design presented here, based on the Arduino Uno microcontroller, allows the system to function in two modes: one based on light intensity (day/night mode) and another based on object detection (motion-activated). The system can also be expanded to control doors and monitor objects. A prototype was tested at a lab scale, showing the system's simplicity, reliability, and low cost. The system can be easily scaled for real-world applications in smart cities, homes, agriculture, hospitals, malls, airports, universities, and more.

IX. FUTURE ENHANCEMENTS

- Fault detection in poles using suitable sensors.
- In case of an accident, sensors could detect the event and trigger calls to emergency services like the police and ambulance.
- Traffic congestion detection using cameras.
- Vehicle speed measurement using speed sensors, with automatic reporting to traffic authorities for violations.

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