AUTOMATIC STREET LIGHTING SYSTEM (ASLS)

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***Abstract—*. The Automatic Street Lighting System (ASLS) presented in this paper is an innovative solution using Arduino microcontroller technology, infrared (IR) sensors, Passive Infrared (PIR) sensors, and Light Emitting Diodes (LEDs) to optimize energy efficiency and safety in urban environments. By using IR sensors to detect ambient light levels and PIR sensors to detect motion, the ASLS intelligently activates LED streetlights only during low-light conditions and when human presence is detected, ensuring energy conservation while enhancing visibility and safety for pedestrians and motorists. The Arduino microcontroller serves as the central processing unit, allowing for customizable control parameters to adapt to various environmental conditions and requirements. This system offers significant benefits including energy savings, improved safety, cost-effectiveness, and scalability, making it a promising solution for enhancing urban lighting management and sustainability.**

***Index Terms—* Automatic Street Lighting System, ASLS, Arduino microcontroller, infrared sensors**

I. INTRODUCTION

In urban environments, street lighting plays a pivotal role in ensuring safety and security for residents and commuters alike. However, conventional street lighting systems often suffer from inefficiencies, including excessive energy consumption and inadequate responsiveness to changing environmental conditions. To address these challenges, the development of intelligent and energy-efficient solutions has become increasingly imperative. The Automatic Street Lighting System (ASLS) proposed in this paper represents a novel approach towards achieving these objectives by integrating Arduino microcontroller technology, infrared (IR) sensors, Passive Infrared (PIR) sensors, and Light Emitting Diodes (LEDs) to create a responsive and sustainable lighting infrastructure for urban areas.

The ASLS aims to optimize energy usage by employing IR sensors to detect natural light levels and PIR sensors to detect motion or human presence. Through these sensors, the system intelligently activates LED streetlights only when necessary, such as during dusk or in low-light conditions, thereby minimizing energy wastage during daylight hours. This adaptive lighting strategy not only reduces operational costs but also contributes to environmental conservation efforts by decreasing the carbon footprint associated with traditional street lighting systems. By harnessing the power of sensor technology and intelligent control algorithms, the ASLS offers a proactive approach to urban lighting management, ensuring that resources are utilized efficiently while maintaining optimal levels of safety and visibility. Furthermore, the integration of Arduino microcontroller technology enables the ASLS to achieve a high degree of customization and flexibility in its operation. Through programmable parameters, such as sensitivity thresholds and lighting schedules, the system can be tailored to accommodate the unique requirements of different urban environments and adapt to changing conditions over time. This scalability allows for seamless integration with existing infrastructure and facilitates future expansions or modifications as urban landscapes evolve. Additionally, the modular design of the ASLS ensures ease of deployment and maintenance, making it a practical and cost-effective solution for municipalities seeking to upgrade their street lighting systems.

The ASLS represents a significant advancement in urban lighting technology, offering a sustainable and intelligent alternative to conventional street lighting systems. By leveraging sensor technology, LED lighting, and Arduino microcontroller technology, the system maximizes energy efficiency, enhances safety, and promotes environmental sustainability in urban environments. With its adaptive capabilities and customizable features, the ASLS has the potential to revolutionize the way street lighting is managed and implemented, paving the way towards smarter and more resilient cities in the future.

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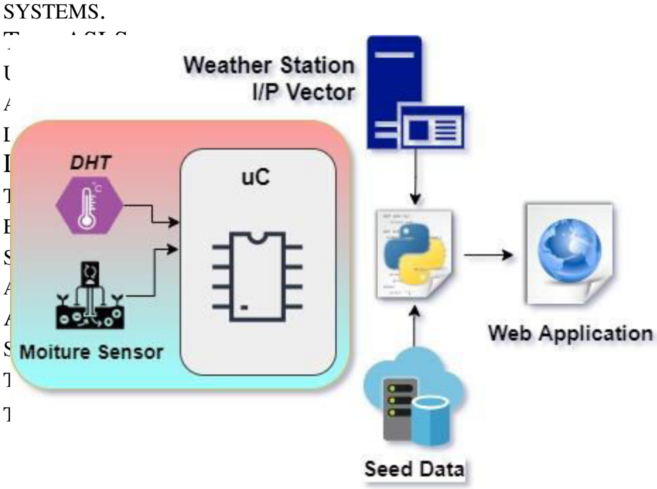

Figure. 1: Block diagram of proposed system

to their longer lifespan, higher effectiveness, lower maintenance costs, and eco-friendliness, as they are mercury-free. Additionally, studies suggest that transitioning to LED lights can result in a 50% reduction in energy consumption for street lighting. Various research endeavors discuss new technologies being developed to control and manage street lights effectively.

Tang, Hengyu [1], proposed a control core framework based on AT89S52 to manage street lights. This framework integrates technologies such as LCD, digital clock, timer, and photosensitive induction. It conserves electricity by turning on lights when vehicles pass by and vice versa, thereby saving a significant amount of power. An auto-alarm function is incorporated into this framework to provide details about malfunctioning lights.

Xudan, Siliang [2], introduced a system utilizing wireless sensor networks to monitor street light progress. The system adjusts based on latitude and longitude information and utilizes sunset and sunrise procedures, as well as light intensity data, to control street lights automatically. Additionally, it employs digital temperature and humidity sensors to monitor real-time conditions.

E.S. Lothar [5] introduced a lighting control system comprising modules like ballast control and data processing modules. The system employs wireless connections to enable the operation and control of light intensity, automatic street light activation, and scheduling through a web browser. S.H. Jeong [6] developed a control.

III. PROPOSED SYSTEM

The proposed system shown in Fig 1 is an Automatic Street Lighting System (ASLS) that integrates cutting-edge technologies to revolutionize urban street lighting infrastructure. At its core lies the Arduino microcontroller, which acts as the central processing unit, allowing for customizable control parameters to adapt to varying environmental conditions and requirements. By leveraging infrared (IR) sensors to monitor ambient light levels and Passive Infrared (PIR) sensors to detect motion or human presence, the ASLS intelligently activates LED streetlights only when necessary, minimizing energy wastage and reducing operational costs. Additionally, the system can

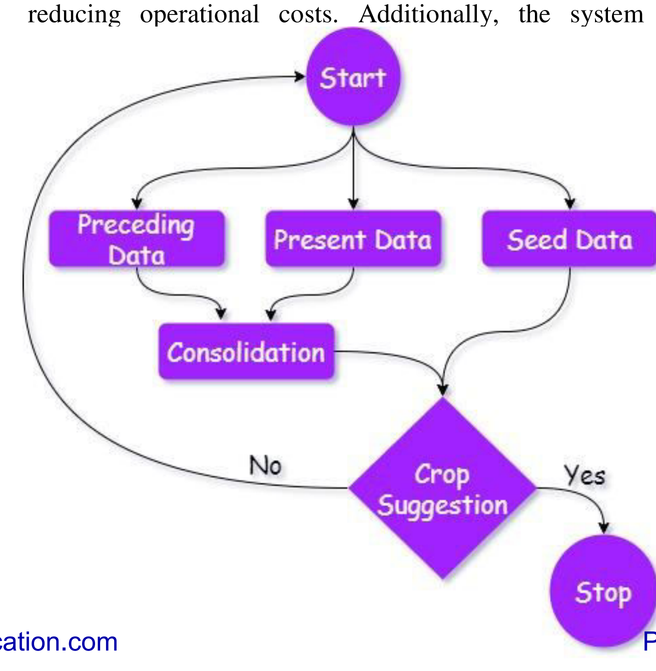

Figure. 2: Process Flow Diagram

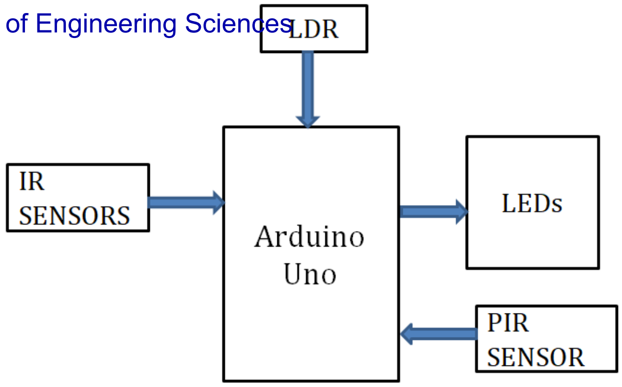

Figure 1 Block diagram of proposed system

IV. COMPONENT DESCRIPTION

A. Arduino Uno

The Arduino Uno, depicted in Fig, is an open-source microcontroller board designed by Arduino.cc, featuring the Microchip ATmega328P chip at its core. This board offers a range of digital and analog input/output (I/O) pins that facilitate connectivity with various expansion modules and circuits. It can be powered via a USB connection or an external 9-volt battery, supporting voltage inputs from 7 to 20 volts. The Arduino/Genuino Uno provides multiple avenues for communication with a computer. Utilizing digital pins 0 (RX) and 1 (TX), the ATmega328 enables UART TTL (5V) serial communication. This serial connection is routed through USB by an ATmega16U2, which is integrated into the board and acts as a virtual COM port for applications on the PC. Moreover, the Uno's digital pins can be configured for serial communication using the Software Serial library, offering additional flexibility in interfacing with external devices.

Fig 2: Arduino uno

B. LDR

The Light Dependent Resistor (LDR) is a type of photoresistor that exhibits a change in resistance based on the intensity of incident light. Typically made of semiconductor materials, the resistance of an LDR decreases as the light level increases, and vice versa. This property makes LDRs ideal for applications such as ambient light sensing, where they are commonly used in automatic lighting systems to detect changes in light levels and adjust illumination accordingly. LDRs are characterized by their high sensitivity to light, wide spectral response range, and low cost, making them a popular choice for various light-sensing applications in electronics, robotics, and environmental monitoring systems.

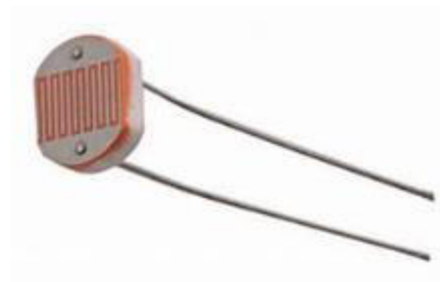

Fig 3: Light Dependent resister

C. IR Sensor

The Infrared (IR) sensor is a device that detects infrared radiation emitted or reflected by objects. It operates based on the principle that all objects emit infrared radiation as a form of heat energy. IR sensors typically consist of an IR emitter and an IR detector, which work together to detect changes in the surrounding environment. When an object comes within the detection range of the sensor, it absorbs or reflects the emitted infrared radiation, causing a change in the sensor's output signal. IR sensors find applications in various fields, including proximity sensing, object detection, motion detection, temperature measurement, and remote control systems. They are commonly used in electronic devices such as burglar alarms, automatic doors, robotics, and smart appliances, where their ability to detect the presence or movement of objects without physical contact is highly valuable.

Fig 4: Infrared Sensor

D. PIR sensor

The Passive Infrared (PIR) sensor is a type of motion sensor that detects changes in infrared radiation emitted by objects within its detection range. Unlike active sensors that emit their own energy to detect motion, PIR sensors passively monitor the infrared radiation emitted by objects in their field of view. PIR sensors typically consist of a pyroelectric sensor, which generates an electric charge in response to changes in infrared radiation, and a circuit that processes this signal to detect motion. When an object moves within the sensor's detection range, it causes a change in the infrared radiation pattern detected by the pyroelectric sensor, triggering the sensor to output a signal indicating motion. PIR sensors are widely used in security systems, lighting control systems, automatic doors, and occupancy detection systems due to their high sensitivity, low cost, and ease of integration. They offer reliable detection of human presence or movement without the need for physical contact, making them essential components in various applications where motion sensing is required.

Fig 5: Passive Infrared Sensor

E. LED

Light Emitting Diodes (LEDs) are semiconductor devices that emit light when an electric current passes through them. LEDs are characterized by their efficiency, durability, and versatility, making them popular lighting solutions in various applications. Unlike traditional incandescent bulbs, LEDs do not rely on heating a filament to produce light, resulting in significantly lower energy consumption and longer lifespan. LEDs are available in a wide range of colors, including red, green, blue, and white, and can be used for various purposes, including general illumination, signage, automotive lighting, and backlighting in electronic displays. In addition to their energy efficiency and longevity, LEDs offer instant illumination, dimmability, and the ability to produce vibrant colors, making them ideal for both residential and commercial lighting applications. As technology advances, LEDs continue to evolve, offering even greater efficiency, brightness, and color accuracy, further cementing their position as the lighting technology of choice for the future.

Fig 6: Light Emitting Diode

V. Implementation circuit

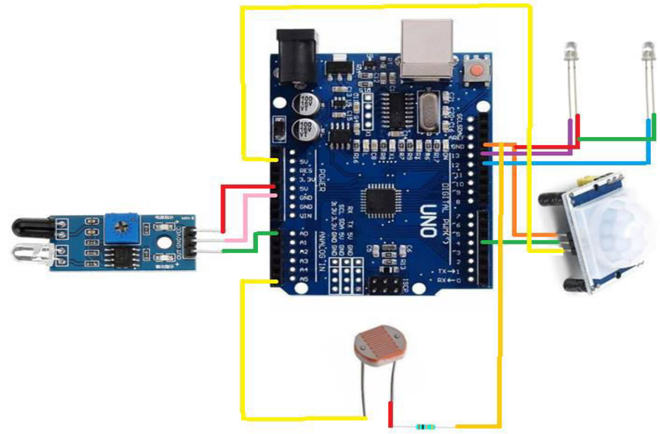

Fig 6: Interfacing circuit

Here are the step-by-step instructions for connecting the sensors and LEDs to the Arduino Uno:

LDR Sensor:
Insert the LDR sensor into the breadboard.
Connect one leg of the LDR sensor to the +5V pin of the Arduino using a jumper wire.
Connect the other leg of the LDR sensor to analog pin A5 of the Arduino, as well as one pin of a 10 kΩ resistor.
Connect the other pin of the 10 kΩ resistor to the GND pin of the Arduino.
PIR Sensor:
Connect the Vcc pin of the PIR sensor to the +5V pin of the Arduino.
Connect the GND pin of the PIR sensor to the GND pin of the Arduino.
Connect the output wire of the PIR sensor to digital pin 4 of the Arduino.
IR Sensor:
Connect the Vcc pin of the IR sensor to the +5V pin of the Arduino.
Connect the GND pin of the IR sensor to the GND pin of the Arduino.
Connect the output pin of the IR sensor to analog pin A0 of the Arduino.
LED Connections:
Insert LED1 into the breadboard and connect its long, positive leg (anode) to digital pin 13 of the Arduino.
Connect the short, negative leg (cathode) of LED1 to the GND rail of the breadboard.
Insert LED2 into the breadboard and connect its long, positive leg (anode) to digital pin 12 of the Arduino.
Connect the short, negative leg (cathode) of LED2 to the GND rail of the breadboard.

VI. Algorithm

1. Initialize the LDR sensor, IR sensor, PIR sensor, and LED pins in the Arduino code.
2. Declare variables to store sensor readings: LDRValue, IRSensorValue, and PIRSensorValue.

3. Set the LED pin as an output using pinMode(LEDpin, OUTPUT).
4. Set the LDR sensor pin, IR sensor pin, and PIR sensor pin as inputs using pinMode(LDRpin, INPUT), pinMode(IRSensorPin, INPUT), and pinMode(PIRSensorPin, INPUT), respectively.
5. Enter an infinite loop using while (1) or for (;;) to continuously monitor sensor readings and control the LED.
6. Read the LDR sensor value using analogRead(LDRpin) and store it in LDRValue.
7. Read the IR sensor value using digitalRead(IRSensorPin) and store it in IRSensorValue.
8. Read the PIR sensor value using digitalRead(PIRSensorPin) and store it in PIRSensorValue.
9. Check if the LDR sensor value is below a certain threshold indicating darkness and if both the IR and PIR sensor values indicate no motion.
10. If the conditions in the previous step are true, turn on the LED by writing digital Write(LEDpin, HIGH).
11. If the conditions in the previous step are false, turn off the LED by writing digital Write(LEDpin, LOW).
12. Add a delay using delay(milliseconds) to control the frequency of sensor readings and LED updates.
13. Repeat steps 6-12 indefinitely to continuously monitor sensors and control the LED based on the detected conditions.

VII. Results

The following figures illustrate the outcomes of the automatic street lighting system in action. When there are no objects or vehicles moving on the road, the lights will either be dimmed or completely turned off to conserve energy.

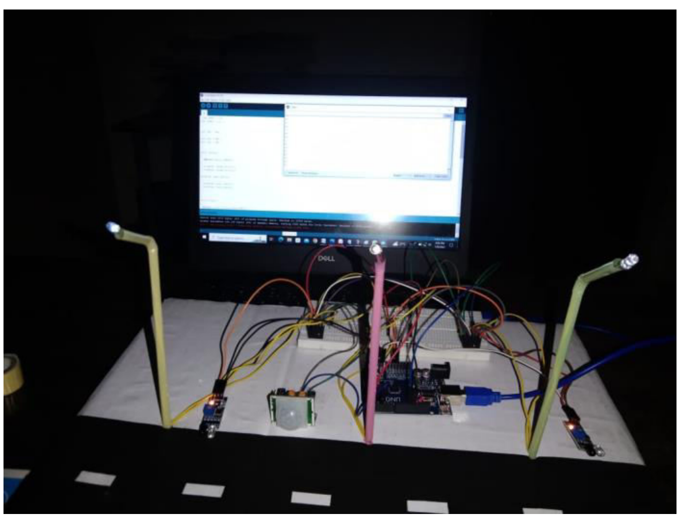

Fig 7: Outcome of Automatic Street Lighting System with Dim/OFF State When No Objects/Vehicles are in Motion

When an object is detected by the IR sensor, the light will illuminate brightly.

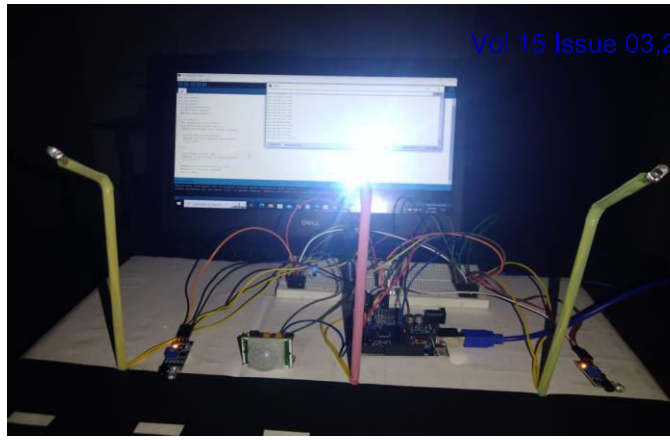

Fig 8: Bright Illumination Triggered by IR Sensor Detection

When an object is detected by the PIR sensor, the light will shine brightly.

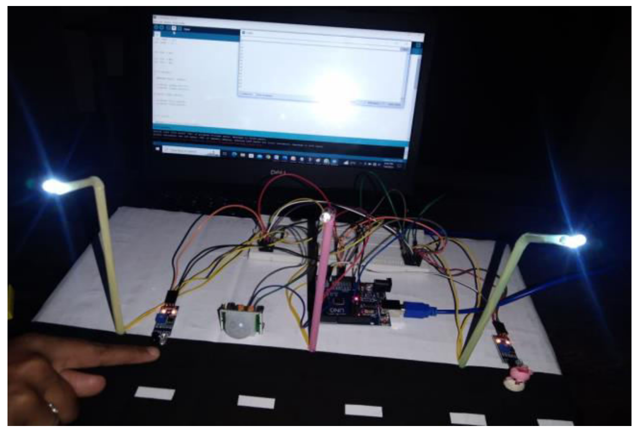

Fig 9 : while using the PIR Sensor

VIII. Conclusion

In conclusion, the integration of sensors such as IR and PIR sensors into the automatic street lighting system presents a significant advancement in urban lighting management. By leveraging these sensors, the system can detect the presence of objects or motion accurately, allowing for efficient control of street lighting. When objects are detected, whether by the IR sensor or the PIR sensor, the lights illuminate brightly, ensuring adequate visibility and safety for pedestrians and motorists. Conversely, when no objects or motion are detected, the system intelligently dims or turns off the lights, conserving energy and reducing unnecessary illumination. This adaptive and responsive approach not only enhances energy efficiency but also contributes to the overall sustainability and effectiveness of urban street lighting systems, ultimately leading to safer and more environmentally friendly urban environments.

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