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Automatic Street Lighting with Smart Zebra Crossing System

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Abstract: This study presents the design and implementation of an intelligent street lighting system integrated with a smart zebra crossing mechanism aimed at improving pedestrian safety and reducing energy consumption. Conventional lighting systems operate continuously without considering environmental conditions, resulting in unnecessary power usage. In the proposed system, a Light Dependent Resistor (LDR) is used to monitor ambient light intensity, while Infrared (IR) or ultrasonic sensors are employed to detect pedestrian presence. A microcontroller processes these inputs and controls street lights and warning indicators accordingly. When a pedestrian is detected near the crossing, visual alerts are activated to warn approaching vehicles. The system operates only when required, thereby conserving energy and enhancing safety. "The proposed solution is cost-effective and suitable for modern smart city applications.''

Keywords: Automatic street lighting, smart zebra crossing, LDR sensor, pedestrian detection, energy efficiency, Arduino.

I. INTRODUCTION

Street lighting is essential for maintaining visibility and ensuring road safety during night-time and low-light conditions. However, traditional street lighting systems generally operate continuously throughout the night without considering traffic density or pedestrian activity, leading to excessive energy consumption. In addition, most conventional zebra crossings do not provide active warning mechanisms, increasing the risk of accidents, especially in poorly lit areas.

To address these challenges, there is a need for an adaptive system that responds dynamically to real-time environmental and traffic conditions. This work proposes an integrated solution that combines automatic street lighting with a smart pedestrian crossing system. The system utilizes an LDR sensor to detect ambient light levels and IR or ultrasonic sensors to identify pedestrian movement near the crossing area.

Based on the sensor inputs, a microcontroller controls the operation of street lights and activates warning signals when pedestrians are detected. This coordinated approach improves road safety while optimizing energy usage. The proposed system is simple, efficient, and suitable for both urban and rural applications.

II. RELATED WORK

Earlier research has mainly focused on improving the efficiency of street lighting systems using automation techniques. Initial approaches employed LDR sensors to automatically switch lights ON and OFF based on day and night conditions, reducing manual effort and saving electricity. Later, motion detection technologies using IR and ultrasonic sensors were introduced to detect vehicle movement and control lighting accordingly.

Recent developments have explored IoT-based street lighting systems, which enable remote monitoring and intelligent control, thereby enhancing system performance and flexibility. Although these systems improve energy efficiency, they often give limited attention to pedestrian safety.

To enhance road safety, smart zebra crossing systems have been developed using sensors and microcontrollers to detect pedestrians and provide warning signals to drivers. Some advanced systems incorporate cameras and machine learning algorithms; however, these solutions are often expensive and complex to implement.

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Therefore, there is a need for a unified system that integrates both energy-efficient lighting and pedestrian safety features into a single, cost-effective solution.

III. LITERATURE REVIEW

Previous studies on street lighting mainly focused on automatic control using LDR sensors, which switch lights ON OFF based on surrounding light conditions. This approach helps in reducing energy consumption and manual operation. Later, motion sensors such as IR and ultrasonic sensors were introduced to detect vehicle movement and improve system efficiency.

Recent research has explored IoT-based smart lighting systems that allow remote monitoring and better control. However, most of these systems mainly focus on energy saving and give less importance to pedestrian safety.

Some works have proposed smart zebra crossing systems that detect pedestrians and provide warning signals to vehicles. Although advanced methods like camera-based detection exist, they are often complex and costly.

Therefore, there is a need for a simple and cost-effective system that combines both automatic street lighting and pedestrian safety features in a single solution.

IV. CASE STUDY

1.1 In Automatic Street Light:

The automatic street light system uses an Arduino microcontroller to control street lights automatically. A power supply provides power to the circuit. The LDR sensor detects day and night conditions; during the daytime the lights remain OFF, and at night the system becomes active. Four IR sensors are used to detect the movement of vehicles or people on the road. When any IR sensor detects movement, the Arduino turns ON the corresponding LED street light. After the vehicle passes, the LED turns OFF automatically. This system helps in saving electrical energy and provides efficient street lighting.

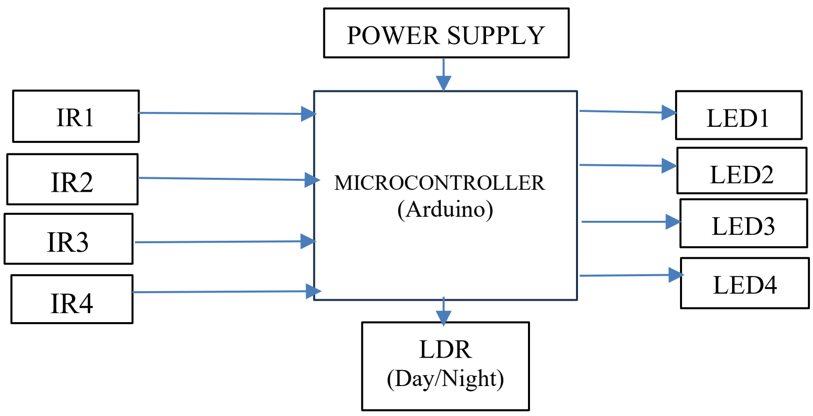

Fig. 1.1 Block Diagram

1.2 Smart Zebra Crossing:

This block diagram represents the control system of a Smart Zebra Crossing and Automatic Street Light project.

The system uses two IR sensors to detect the presence of a pedestrian or object near the crossing area. When the sensors detect movement, the signal is sent to a transistor driver, which amplifies the signal and sends it to the timer module. The timer module controls the time duration for which the signal will remain active.

The output of the timer is connected to a relay module, which switches between two indicators. When the relay activates, the red LED (NC) turns ON to stop vehicles, allowing pedestrians to cross safely. After the timer finishes, the relay switches back and the green LED (NO) turns ON, allowing vehicles to move again.

All the modules in the system operate using a +5V power supply. Overall, this block diagram shows how sensors, timer, and relay work together to control traffic signals and improve pedestrian safety at a zebra crossing.

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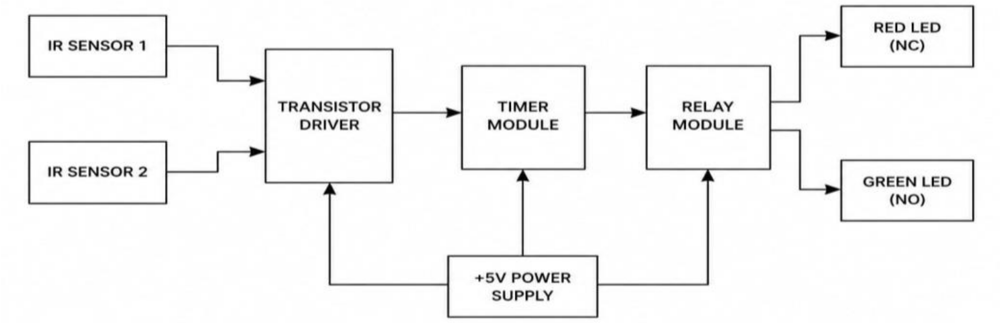

Fig. 1.2 Block Diagram

2.1 **Arduino- Microcontroller:**

Fig. 2.1. Arduino UNO

Arduino Uno is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is fitted with a set of digital input and analog / output (I / O) pins connected to various expansion boards (shields) and other circuits. The board has 14 Digital pins, 6 Analog pins, and is programmed with Arduino IDE (Integrated Communication Area) on a USB type B. It can be supplied with a USB cable or 9-volt external battery.

2.2 IR Sensor Module:

Fig. 2.2. IR Sensor Module

The IR sensor is used to detect the presence of pedestrians near the zebra crossing. Upon detection, it sends a signal to the control unit, which activates warning lights to alert approaching vehicles.

2.3 LDR (Light Dependent Resistor):

Fig. 2.3. LDR (Light Dependent Resistor)

The LDR is used to monitor ambient light conditions and control the operation of street lights. It ensures that the lights are activated during low-light conditions and remain OFF during daylight, thereby conserving energy.

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2.4 Digital Timer Relay Module:

Fig. 2.4. Digital Timer Relay Module

A digital timer relay module is used to control the timing of electrical devices. It allows the system to switch lights ON and OFF automatically after a set duration. In this project, it ensures that the zebra crossing lights remain active for a specific time and then turn OFF without manual control.

2.5 Light Emitting Diode:

LEDs are used due to their high efficiency and ease of control through sensor inputs. The system can also regulate LED brightness when a vehicle is detected, thereby reducing glare and enhancing driving safety during night conditions.

LEDs are used as street lights and as indicators at the zebra crossing. The **green LED** can show that it is safe for pedestrians to cross, while the **red LED** can warn vehicles to stop. The LEDs turn ON automatically based on sensor signals.

V. METHODOLOGY

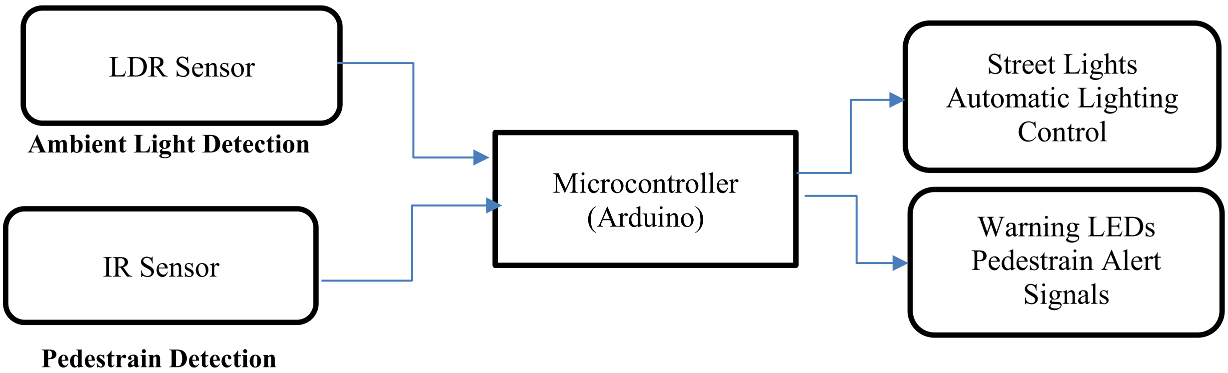

Fig. 5.1. Block Diagram of Automatic Street Lighting With Smart Zebra Crossing System

Fig. 4.1 The proposed system is composed of three main units: sensing components, a control unit, and output devices. Initially, an LDR sensor is used to measure the intensity of surrounding light. When the ambient light level falls below a predefined threshold, the street lights are automatically switched ON. During daytime or sufficient lighting conditions, the lights remain OFF to conserve energy.

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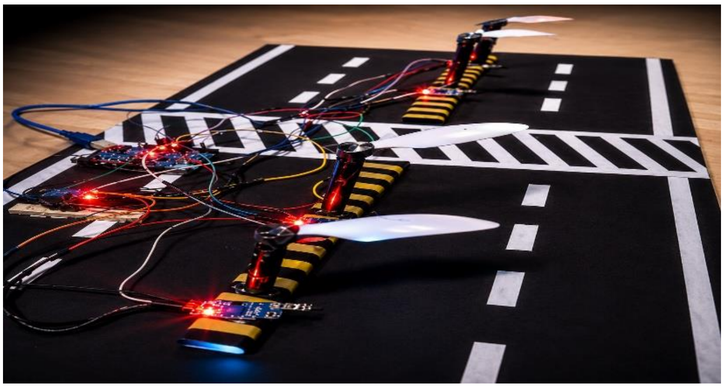
For pedestrian detection, IR sensors are installed near the zebra crossing. These sensors identify the presence of pedestrians and send corresponding signals to the microcontroller. The microcontroller serves as the central processing unit, analyzing the received data and making control decisions.

When a pedestrian is detected, LED warning indicators are activated to alert approaching vehicles. These indicators remain active for a fixed duration or until the pedestrian has safely crossed the road. Once the crossing is clear, the warning signals are automatically turned OFF.

This integrated operation ensures efficient energy utilization while significantly enhancing pedestrian safety.

VI. EXPERIMENTAL RESULT

3.1 In Automatic Street Light:



This Fig. shows a small road model with a zebra crossing. The system uses sensors, wires, and LED lights connected to a controller. When a person comes near the crossing, the lights turn ON to warn drivers. The red lights signal vehicles to stop, allowing the pedestrian to cross safely. The system works automatically without human control.

During night time, the street lights turn ON to improve visibility. The sensors help detect movement near the crossing area. When a vehicle or object passes, the system responds based on the sensor input. This helps in smooth traffic movement and better control. Overall, this model helps improve road safety and reduces accidents.

This Fig. shows a road model with a zebra crossing and street lights. Electronic components like sensors, wires, and LEDs are used in the system. When a pedestrian comes near the crossing, the lights turn on to alert drivers. The glowing lights help vehicles slow down or stop, allowing safe crossing. The system works automatically and improves road safety.

`During night time, the street lights provide better visibility for both drivers and pedestrians. The sensors continuously monitor the crossing area and detect any movement. Based on this detection, the system controls the lights to ensure smooth traffic flow. This setup reduces manual effort and increases overall safety on the road.

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This Fig. shows a smart road model with a zebra crossing and street lights. The system uses sensors, LEDs, and a controller. During night time, the street lights turn ON automatically.

When an object or vehicle comes in front of the sensor, the LED light becomes dim or turns OFF to allow the vehicle to pass easily and reduce power usage. When no object is detected, the light turns ON again.

When a pedestrian is near the zebra crossing, the lights glow to warn drivers. This helps vehicles slow down or stop, so pedestrians can cross safely. The system works automatically and improves road safety.

3.2 Smart Zebra Crossing

This Fig. shows a Smart Automatic Street Light with Zebra Crossing Safety System model. The system is designed to improve road safety for both cars and pedestrians.

A zebra crossing is provided for humans to cross the road safely, while a traffic signal with red and green lights and a timer controls vehicle movement.

When pedestrians cross, the signal turns red so cars stop, and after the timer ends, the signal turns green allowing vehicles to move again. Street lights are installed on both sides of the road and operate automatically based on light conditions to save energy.

Overall, the model demonstrates how smart lighting and traffic control can improve pedestrian safety and reduce accidents.

VII. ADVANTAGES

1. Improves road safety for both pedestrians and drivers.
2. Provides clear signals at zebra crossings to avoid confusion.
3. Reduces the chances of accidents, especially at night.
4. Saves energy by controlling street lights automatically.
5. Works without human involvement, reducing manual effort.
6. Gives quick response when a pedestrian is detected.
7. Helps drivers identify crossing zones easily.

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8. Ensures better visibility in low-light conditions.
9. Supports smooth traffic movement on the road.
10. Can be implemented at low cost using simple components.
11. Reduces unnecessary power consumption.
12. Increases efficiency of street lighting systems.

VIII. CONCLUSION

The proposed system offers an effective solution for improving pedestrian safety while minimizing unnecessary energy consumption. By integrating automatic street lighting with a smart zebra crossing mechanism, the system ensures that lighting and warning signals are activated only when required. The use of sensors and a microcontroller enables real-time monitoring and control, making the system efficient and reliable. Additionally, the solution is cost-effective and easy to implement in both urban and rural environments. Future enhancements may include IoT-based monitoring and advanced sensing techniques for further improvement.

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