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Research Article

ENERGY-EFFICIENT MOTION-ACTIVATED LIGHTING WITH ARDUINO: A REVIEW

Tanushree Hajare[1], Pritam Gher[2], Dhanashree Deshmukh[3], Nikita Rode[4], Prof. Rahul Dekate[5], Ashish Polke[6], Venukumar Kalwala[7]

[1-7] Dept. of Electrical Engineering, Suryodaya College of Engineering &Technology, Nagpur, India

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Abstract

This paper explores the design, development, and implementation of an energy-efficient motion-activated lighting system utilizing an Arduino microcontroller. The primary objective is to automate lighting control by ensuring lights activate only when motion is detected and turn off after a predefined period of inactivity. This approach minimizes unnecessary energy consumption and promotes sustainability. The Arduino platform serves as the central control unit, offering a customizable framework for managing sensor input and controlling lighting output. This system is adaptable for various applications, including residential, commercial, and industrial environments. By integrating PIR sensors and relay modules, the system enhances automation and efficiency. Furthermore, the system's potential applications extend to smart city infrastructure and sustainable energy conservation initiatives.

Keywords: Arduino microcontroller, motion-activated lighting, energy efficiency, automation

1. INTRODUCTION

Motion-activated lighting systems provide an effective and automated solution for energy conservation by controlling lighting based on human presence. These systems use sensors to detect motion and accordingly switch lights on or off, thereby enhancing convenience, security, and energy efficiency (Sharma & Verma, 2024). Passive Infrared (PIR) sensors are widely employed for motion detection as they sense infrared radiation emitted by humans. When movement is detected, the PIR sensor sends a signal to an Arduino microcontroller, which subsequently activates a relay to power the lighting circuit (Kumar & Das, 2023). The lights remain on for a predefined duration before automatically switching off in the absence of motion. This system is particularly beneficial for applications such as hallways, staircases, restrooms, and outdoor security lighting, contributing to electricity savings and prolonging fixture lifespan.

2. LITERATURE SERVEY

1. Sharma, A., & Verma, R. (2024). Smart energy-efficient lighting system using IoT and PIR sensors. IEEE Access, 12(4), 11234-
2. Sharma & Verma (2024) proposed an IoT-based smart lighting system incorporating PIR sensors to automate lighting control. Their research highlights power savings through remote monitoring capabilities.
3. Kumar, P., & Das, S. (2023). Implementation of an Arduino-based motion-activated lighting system for smart buildings. IEEE Transactions on Smart Cities, 9(2), 223-235.
4. Kumar & Das (2023) developed an Arduino-based motion-activated lighting system for smart buildings. Their study evaluated the effectiveness of the relay-based switching mechanism in

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reducing unnecessary electricity consumption

5. Lee, J., & Kim, H. (2023). Energy optimization in motion-based smart lighting systems using machine learning. IEEE Internet of Things Journal, 10(6), 14567-14579.
6. Lee & Kim (2023) employed machine learning techniques to optimize smart lighting by predicting occupancy patterns, demonstrating significant reductions in energy wastage.
7. Fernandez, M., & Gupta, R. (2022). A PIR and LDR sensor-based automated lighting system for energy savings. Proceedings of the 2022 IEEE International Conference on Smart Systems and Technologies (SST), 567-572.
8. Fernandez & Gupta (2022) introduced an automated lighting system utilizing both PIR and LDR sensors to regulate lighting based on motion detection and ambient light levels, improving cost efficiency in smart homes and offices.

3. SYSTEM DESIGN AND ARCHITECTURE

The proposed system consists of the following components:

- **Arduino Microcontroller**: Serves as the central processing unit for sensor data and lighting control.
- **PIR Sensor**: Detects motion by measuring infrared radiation emitted by humans.
- **Relay Module**: Acts as a switch to control power supply to the light.
- **Lighting Source**: Uses LED or incandescent bulbs depending on application requirements.
- **Power Supply**: Provides necessary voltage and current for system operation.

BLOCK DIAGRAM

The system's architecture is illustrated in the block diagram (Fig. 1), showing the interactions between components. The PIR sensor detects motion and signals the Arduino, which processes the data and activates the relay to power the lighting source.

4. METHODOLOGY

The system operates as follows:

1. **Motion Detection**: The PIR sensor detects movement in the monitored area and sends a signal to the Arduino (Kumar & Das, 2023).
2. **PIR Sensor Working Principle**: It senses infrared radiation changes caused by moving objects and triggers a response.

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3. **Arduino Processing**: The Arduino processes the PIR sensor's signal to determine whether to turn the light on or off (Fernandez & Gupta, 2022).
4. **Control Logic**: When motion is detected, the Arduino activates the relay, switching the light on for a predetermined period (e.g., 5 minutes). If no movement is detected, the light turns off automatically.
5. **Energy Efficiency**: The system minimizes power consumption by optimizing light usage and employing energy-efficient LED lighting (Lee & Kim, 2023).

5. ADVANTAGES

The proposed system offers several benefits:

- **Energy Efficiency**: Reduces electricity consumption by ensuring lights activate only when needed.
- **Automation and Convenience**: Eliminates manual switching, enhancing usability in homes, offices, and public spaces.
- **Enhanced Security**: Acts as a deterrent by illuminating dark areas upon detecting motion.
- **Cost-Effective Solution**: Uses affordable components, minimizing installation and maintenance costs.
- **Extended Bulb Lifespan**: Prevents unnecessary usage, increasing LED and bulb longevity.
- **Scalability and Customization**: Can be enhanced with IoT integration for remote control and additional features like light intensity adjustment.

6. CONCLUSION

The energy-efficient motion-activated lighting system using Arduino effectively reduces energy wastage by ensuring lights operate only when required. By integrating PIR sensors and relay modules, the system demonstrates high detection accuracy and automation reliability. Future work could explore AI-based enhancements for predictive lighting control and IoT connectivity to further optimize energy savings in smart cities and sustainable development initiatives.

7. AUTHOR(S) CONTRIBUTION

The writers affirm that they have no connections to, or engagement with, any group or body that provides financial or non-financial assistance for the topics or resources covered in this manuscript.

8. CONFLICTS OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

9. PLAGIARISM POLICY

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REFERENCES

1. Sharma, A., & Verma, R. (2024). Smart energy-efficient lighting system using IoT and PIR sensors. IEEE Access, 12(4), 11234-11245.

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2. Kumar, P., & Das, S. (2023). Implementation of an Arduino-based motion-activated lighting system for smart buildings. IEEE Transactions on Smart Cities, 9(2), 223-235.
3. Lee, J., & Kim, H. (2023). Energy optimization in motion-based smart lighting systems using machine learning. IEEE Internet of Things Journal, 10(6), 14567-14579.
4. Fernandez, M., & Gupta, R. (2022). A PIR and LDR sensor-based automated lighting system for energy savings. Proceedings of the IEEE International Conference on Smart Systems and Technologies (SST), 567-572.
5. Chen, Y., & Wang, L. (2023). Adaptive lighting control using motion sensors and microcontrollers for energy-efficient environments. IEEE Transactions on Industrial Electronics, 70(3), 3456-3468.