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Motion Sensor - Controlled Fan using PIR Sensor and Arduino

Bhagyavanti Hebbal
UG Scholar, Department of Electrical and Electronics Engineering
P D A College of Engineering Kalaburagi, Karnataka, India

Dr. Sangamesh G Sakri
Project Guide & Professor, Dept. of Electrical and Electronics Engineering
P D A College of Engineering, Kalaburagi, Karnataka, India

Abstract - This research work presents the design and development of an automatic fan control system based on human motion detection using a Passive Infrared (PIR) sensor and an Arduino microcontroller. The system turns the fan ON when motion is detected and switches it OFF after a predefined delay when no motion is present. The objective is to reduce electricity wastage in residential and institutional environments while improving convenience. The hardware consists of a PIR sensor, relay module, and Arduino, forming a compact and cost-effective automation solution. Experimental results show accurate motion detection, stable switching performance, and noticeable energy savings. The proposed system is simple, reliable, and suitable for real-world and academic applications.

Keywords - PIR Sensor, Motion Detection, Arduino, Fan Automation, Relay Module, Energy Efficiency

I. INTRODUCTION

Residential and commercial buildings often experience unnecessary power consumption due to fans being left switched on even when the space is unoccupied. Automation using motion sensing provides an efficient solution for minimizing energy wastage. This research focuses on controlling a fan automatically using a PIR sensor and Arduino. The PIR sensor detects human movement based on infrared radiation changes. When motion is detected, the signal is processed by Arduino, which triggers a relay to switch the AC fan ON. If no motion is detected for a preset duration, the system turns the fan OFF. This method reduces manual effort, enhances convenience, and ensures optimal power usage.

Literature Review

PIR sensors are widely used in automated lighting and security applications. Earlier studies indicate that occupancy-based control systems significantly reduce electricity consumption in buildings. Arduino-based embedded systems are increasingly used for low-cost automation projects due to their ease of programming and versatility. Prior works mainly focused on lighting control; however, fan automation receives relatively less attention despite its high usage in warm climates. This project bridges that gap by integrating PIR sensing with relay switching for efficient fan control.

➤ ***Contactless & Safe Appliance Control***

Goal: To avoid manual switching and provide a safe automation system without the risk of electric shocks or switching errors.

Mechanism (Relay Module): The relay works as an electronic switch that isolates the high-voltage fan circuit from the low-voltage Arduino control circuit. When activated by Arduino, the relay connects the fan to the power supply safely and automatically.

➤ ***Energy-Efficient Operation using Delay Logic***

Goal: To prevent frequent ON/OFF switching and maintain comfort while ensuring energy savings.

Mechanism (Time Delay in Code): A programmed delay timer in Arduino keeps the fan ON for a fixed duration even after the last detected motion. If no motion occurs during this period, the fan turns OFF automatically.

II. METHODOLOGY

- The operation of the proposed system follows these steps:
- The PIR sensor continuously monitors its surrounding area.
- When motion is detected, the sensor outputs a HIGH signal.
- Arduino reads this signal and activates the relay module.
- The relay switches ON the AC fan.
- When no motion is detected, a programmable delay timer starts.
- If no motion occurs within the delay period, the Arduino turns OFF the relay, switching off the fan.

This logic prevents rapid ON/OFF switching, ensuring longer hardware life and reliable operation.

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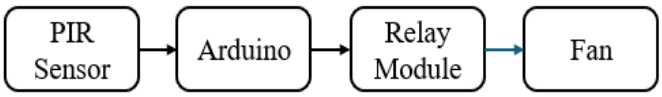
III. BLOCK DIAGRAM



The PIR sensor feeds motion signals into the Arduino. The Arduino processes the input and activates the relay module, which acts as an electrical switch to control the AC fan. The fan remains ON as long as motion is detected and turns OFF after a delay when no further motion is observed.

Hardware Description

- PIR Sensor

Detects infrared radiation variations produced by human movement. It generates a digital output (HIGH/LOW).

- Arduino Microcontroller

Acts as the central processing unit. It reads PIR signals and controls the relay module based on programmed logic.

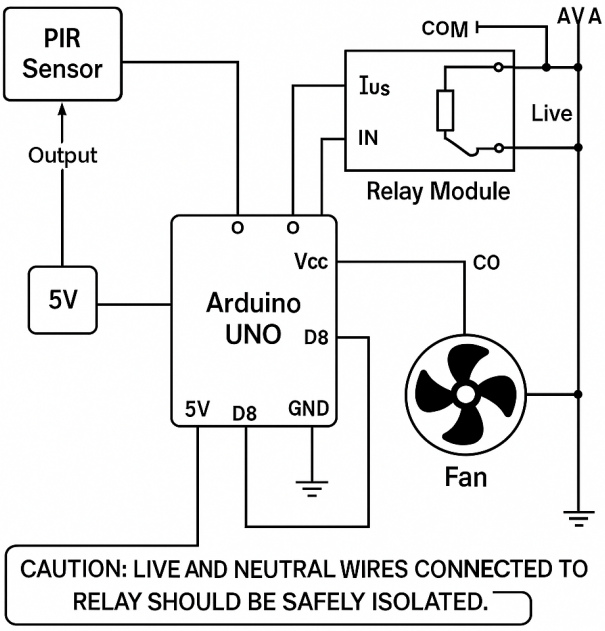
- Relay Module

A 5V electrically operated switch used for controlling the AC fan safely. Ensures proper isolation between high-voltage AC and low-voltage Arduino circuit.

- AC Fan

The load that is automatically controlled. It is connected to the relay's NO (Normally Open) and COM terminals.

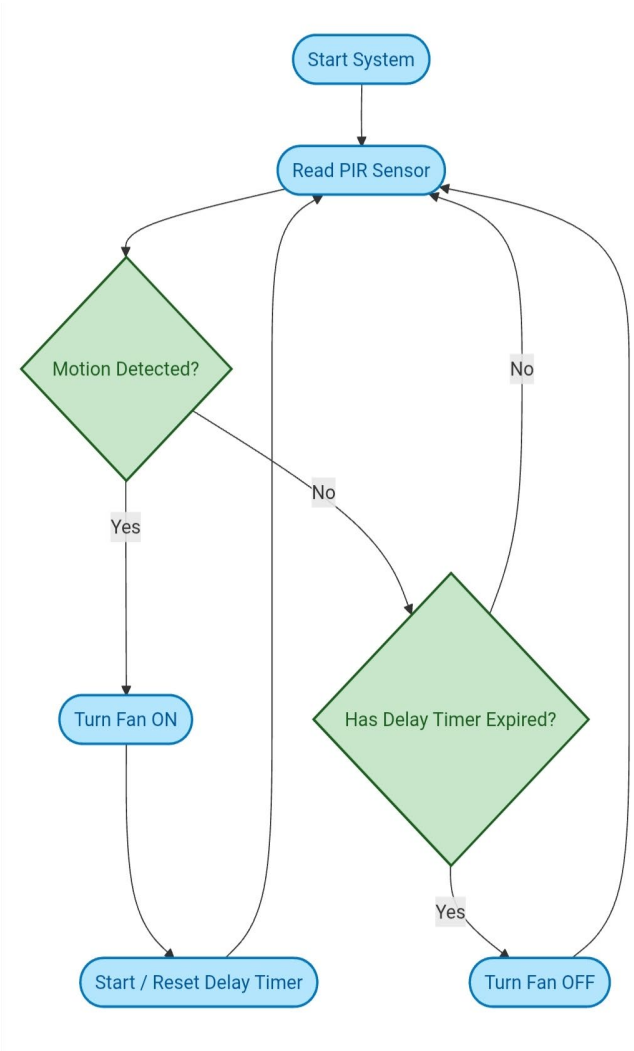
IV. CIRCUIT DIAGRAM



- PIR VCC → Arduino 5V
- PIR GND → Arduino GND
- PIR OUT → Arduino Digital Pin D2
- Relay VCC → Arduino 5V
- Relay GND → Arduino GND
- Relay IN → Arduino Digital Pin D8
- Relay NO/COM terminals connected in series with the AC fan's phase line

The circuit ensures safe and efficient switching between ON/OFF states based on motion input.

V. FLOWCHART



VI. RESULTS AND DISCUSSION

The system was evaluated in multiple indoor environments including a classroom, hostel room, and laboratory to measure accuracy, responsiveness, and energy savings.

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Parameter	Observed Performance
Motion Detection Time	1–2 seconds
PIR Sensor Range	5–6 meters
Detection Angle	~120 degrees
Relay Switching Response	Instantaneous (<100 Ms)
Energy Saved (Daily Avg.)	25–35%
False Trigger Rate	Very Low (1–3% in bright areas)
Delay Time Tested	10s, 30s, 60s (stable)

Discussion

The results indicate that the PIR sensor responds reliably when human motion occurs within its detection zone. During indoor testing, the sensor maintained consistent accuracy, and the Arduino processed signals without delay. The relay module delivered smooth switching with no visible flicker or jitter in fan operation.

In environments with normal lighting, the system performed optimally. However, in areas exposed to direct sunlight or heat-emitting appliances, minor disturbances were observed due to thermal noise affecting the PIR sensor. Adjusting the sensor sensitivity or positioning improved the performance.

Energy consumption analysis showed considerable savings, especially in areas with intermittent human occupancy such as classrooms and hostel rooms. The automatic OFF delay prevented unwanted switching and ensured user comfort while minimizing wasted electricity.

Overall, the system demonstrates high stability, reliability, and substantial potential for real-world deployment in smart automation setups.

VII. CONCLUSION

The proposed motion-controlled fan system using an Arduino microcontroller and PIR sensor is a practical, cost-effective solution for reducing electricity wastage. The system responds accurately to human movement and automatically controls the fan based on occupancy. Experimental results validate the efficiency and reliability of the design. This system can be easily extended to various automation applications in smart homes and institutions.

VIII. FUTURE SCOPE

- Integration with IoT for smartphone-based control
- Variable-speed fan control
- Hybrid sensing using ultrasonic or camera sensors
- Real-time energy monitoring
- Machine-learning-based occupancy prediction

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