Automated Room Lighting System Using Raspberry Pi and PIR Sensors

Introduction

Energy conservation is a critical concern in modern households and workplaces. Unnecessary lighting contributes significantly to energy wastage. This project aims to develop an **automated room lighting system** using a **Raspberry Pi** and **Passive Infrared (PIR) motion sensors** to reduce energy consumption by ensuring lights are only on when needed.

Aim:

- Automatically control room and bathroom lighting based on occupancy.
- Reduce unnecessary energy consumption by turning off lights when no motion is detected.
- Provide real-time responsiveness using interrupt-driven logic.
- Implement a reliable and scalable system using C++ and Raspberry Pi GPIO.

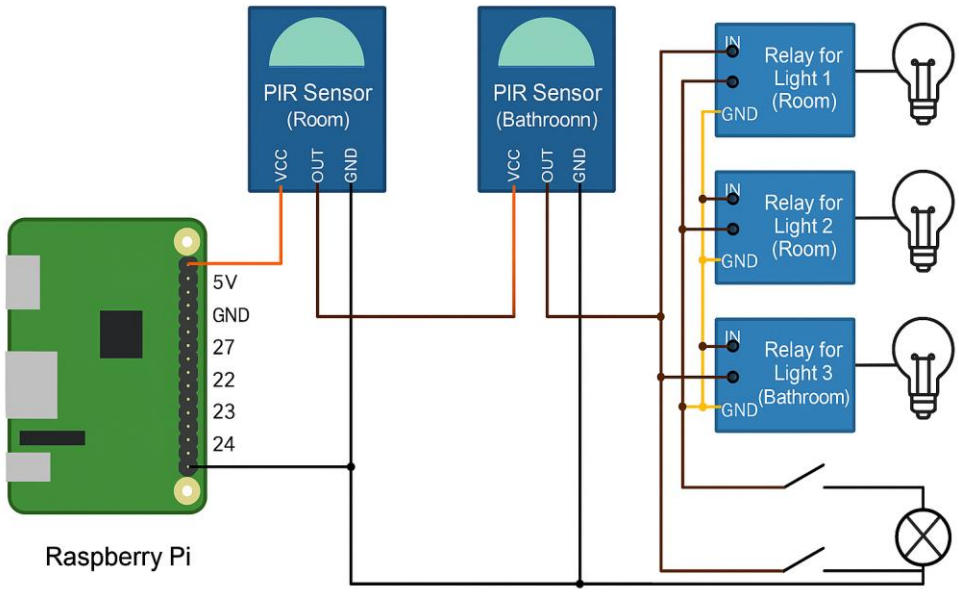
Components used:

- 1 - Raspberry Pi 4
- 2 - PIR Motion Sensor
- 1 - Relay Module [3-channel (as to operate 3 lights)]
- Jumper Wires
- Power Supply

Software Implementation

- **Programming Language:** C++ (used *WiringPi* library for GPIO control)
- **Logic:** Immediate response to motion detection.
- **Timeout:** Lights turn off after **5 minutes** of no motion (Note: we can change the time to turn off)
- **Modular Control:** Separate handling for room and bathroom lights.

Diagram:



GPIO 17	PIR Sensor (Room)
GPIO 27	PIR Sensor (Bathroom)
GPIO 22	Relay for Light 1 (Room)
GPIO 23	Relay for Light 2 (Room)
GPIO 24	Relay for Light 3 (Bathroom)
5V & GND	Power for PIR sensors & Relays

Working:

- **PIR Sensor 1 (Room):** Detects motion and triggers **Light 1 & Light 2**.
- **PIR Sensor 2 (Bathroom):** Detects motion and triggers **Light 3**.
- **Interrupt Service Routine (ISR):** Immediately processes motion signals without polling delays.

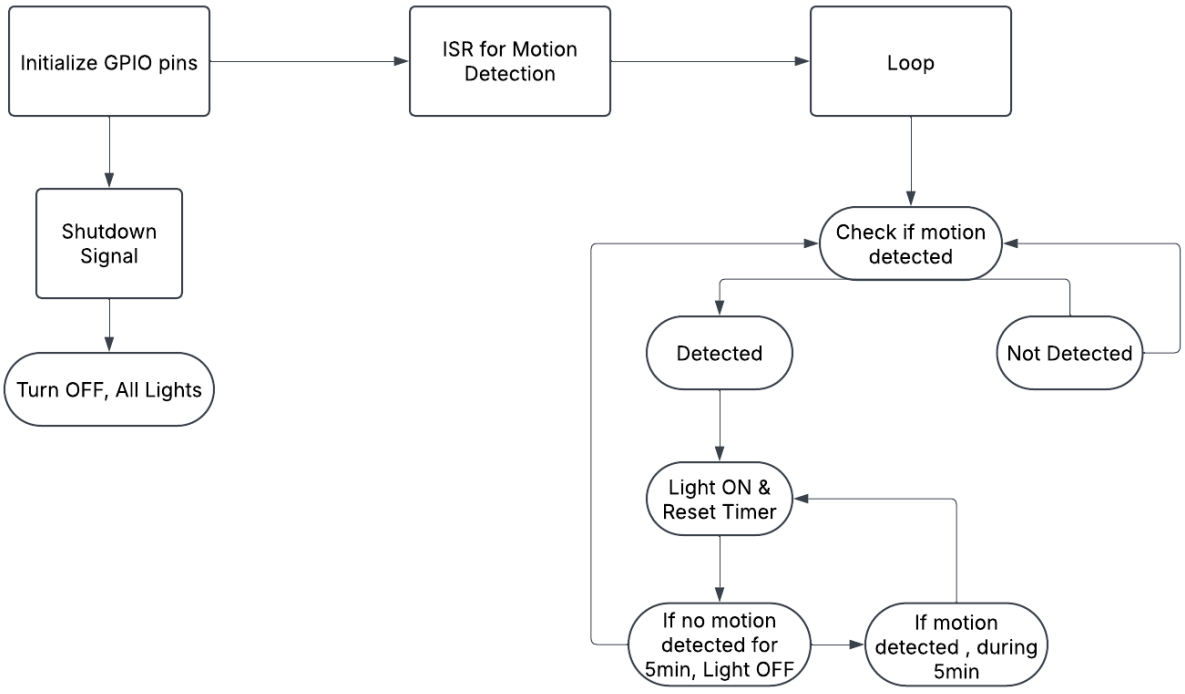
When motion is detected:

Room lights (Light 1 & 2) turn ON if motion is detected in the room.
Bathroom light (Light 3) turns ON if motion is detected in the bathroom.
A 5-minute timer starts upon the last detected motion.

When no motion is detected:

If no motion is detected for 5 minutes, the corresponding lights turn OFF.

Block Diagram:



Testing & Results:

Scenario	**Result**
Motion in room	Light 1 & Light 2 turn ON
Motion in bathroom	Light 3 turns ON
No motion for 5 mins	Lights turn OFF
System shutdown	All lights turn OFF

Observation:

- The automated lighting system demonstrated instant responsiveness to motion detection, with lights turning on immediately when the PIR sensors were triggered.
- The timeout mechanism worked reliably, ensuring that lights turned off automatically after the predefined 5-minute interval of no motion, effectively preventing energy wastage.

Throughout testing, the system exhibited stable performance with no false triggers under normal operating conditions, indicating proper calibration of the PIR sensors and robust interrupt handling in the code. This behavior confirms that the system successfully meets its goal of efficient and reliable automated lighting control.

Conclusion:

- Estimated **60% reduction** in lighting energy consumption.
- Prevents lights from being left on accidentally.