# CasaConnect - A Server Based, Motion Triggered Home Automation System

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## Introduction:

Amidst the rapid advancements achieved in all domains of technology, one of them is gaining momentum ever so fast is home automation - transforming the way people live at home.. Rapid progress has been made in improvising connectivity, detecting external triggers using advanced sensors, and artificial intelligence, thereby improving convenience, efficiency, and the quality of life. An ecosystem of devices work together to handle various aspects of automation from heating and lighting to entertainment and security.

The problem statement is to develop a server based home automation system that can be autonomously triggered using motion sensors specifically for the purpose of turning lights on or off as per the requirement. This entails a system that can detect motion in different parts of the house and automatically turn on or off the lights based on motion detection. It also gives the option of turning the lights on or off from any device using the website hosted by the server.

The development of a server based home automation system with motion sensing capabilities for lighting control addresses several motivations that the world cares about:

a) **Convenience**: The automation of the lighting control based on motion sensing eliminates the need for manual switching of the lights. One can enjoy the convenience of having lights automatically turn on when they enter a room and turn off when they leave the room without the need to find switches or use any physical controls.
b) **Energy Efficiency:** By integrating motion sensing into the lighting control system, unnecessary energy consumption can be reduced. Lights will only be turned off automatically when no motion is detected for a specified period. This helps to conserve energy and lower electricity wastage thus leading to lower electricity bills.
c) **Safety**: Automatic lighting control though motion sensing enhances safety by providing illumination in the areas where motion is detected. This helps to prevent accidents and enables homeowners to navigate their home safely in low light conditions or during night times and need not worry of finding the switch board to turn on the lights.

In developing the server based home automation system with motion sensing capabilities the following steps can be taken:

a) **Hardware Setup**: Install motion sensors in preferred suitable location throughout the home. These Motion Sensors (Passive Infrared Sensor) are connected to the Node MCU which is going to act like our central hub.
b) **Server Setup**:Setting up the Node MCU which is going to host the server using the in built wifi module on the chip, it is able to connect to the central wifi system of the house.The Server is going to receive signals from both the PIR sensors and the direct control command from the user via the website. Then the node MCU sends the required commands to the lighting fixtures.
c) **Integration with lighting fixtures**: Connect the Node MCU with the lighting fixtures in the home.This integration allows the server to control the lights based on the inputs received by the Node MCU module.
d) **Testing and Refinement**: Testing the system to ensure accurate motion detection and reliable lighting control. Testing the achieved outcomes with the expected outcomes to get better knowledge of the thing needed to be worked on and fixed.

## Background and Related work:

1. PIR Sensor :

PIR stands for Passive Infrared Sensor. It is an electronic sensor designed to detect and measure the infrared light emitted by objects.

PIR consist of 3 lead pins:

- VCC (power supply)
- Output
- GND (ground)

PIR sensors contain special materials that can detect infrared radiation and when the detects a change in the infrared radiation pattern, it triggers an electrical signal. The most widely used infrared detector is a pyroelectric detector. PIR sensors consist of Fresnel lenses used as a focusing system for infrared radiation.

PIR has inbuilt sensitivity and delay toggling features. Sensitivity is used to extend the field of view of a PIR sensor ,sensitivity can be increased or decreased according to the model or project used in. Delay determines how long the PIR will keep the OUTPUT “High” after detecting the motion. PIR sensors are sensitive to changes in infrared radiation, mainly affected by change in temperature, sunlight, etc. The range of the PIR sensor is around 7 metres and it has certain limitations, they may not detect motion if the person or object is not within the sensor’s field of view or if the movement is stable. Some common use cases of PIR sensors are in security alarms and sending signals for IOT applications.

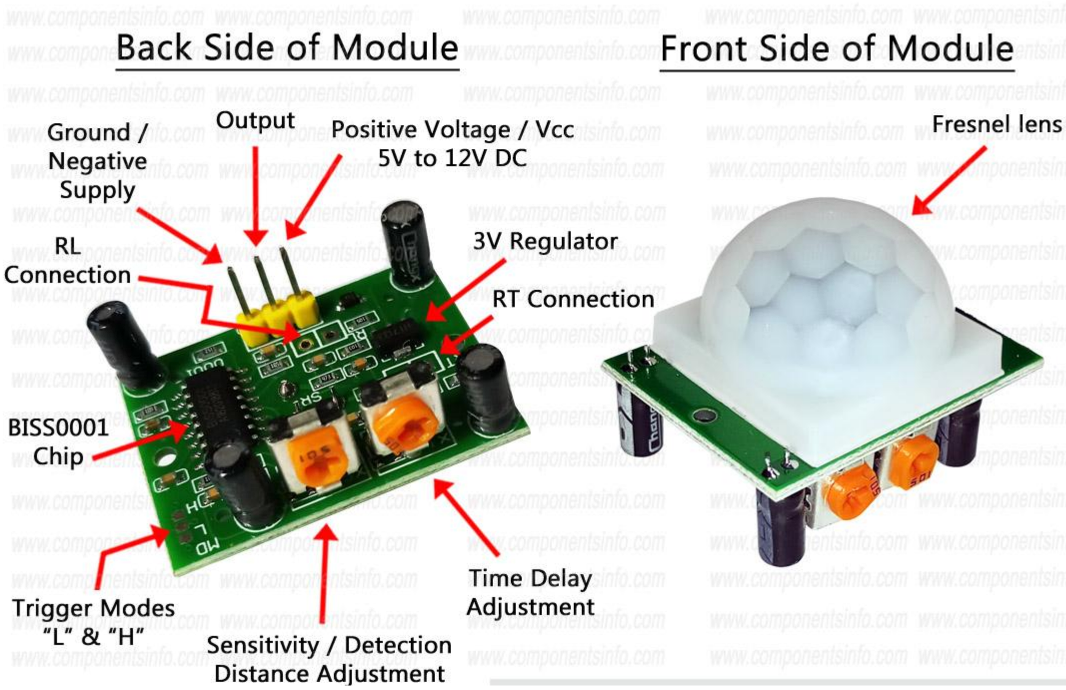



**Figure 1:** Passive Infrared Sensor (PIR)

2. NODE MCU :

Node MCU (ESP-8266) is a microcontroller unit and open source IOT platform. Node MCU can be programmed with Arduino IDE. Node MCU runs on the ESP8266 WiFi- source. It is used for prototyping the IOT devices. NodeMCU is equipped with 128 KB of random-access memory (RAM) and 4 MB of flash memory and 64 KB SRAM memory, providing ample storage capacity for data and programs.This supports RTOS and operates at 80MHz to 160MHz adjustable clock frequency. It operates on 3.3V and average 80mA current with temperature ranging from -40 to 125 celsius. Wifi-connectivity allows one to connect to wireless networks and communicate with other devices over the internet. This makes it suitable for various IOT applications that require connectivity. Node MCU has a number of GPIO pins, which can be used to interface with external devices and sensors. There are 30 pins which includes 17 GPIO pins in NODE MCU. Node MCU has I2C functionality support and UART functionality support. The input voltage of Node MCU is typically 5V.

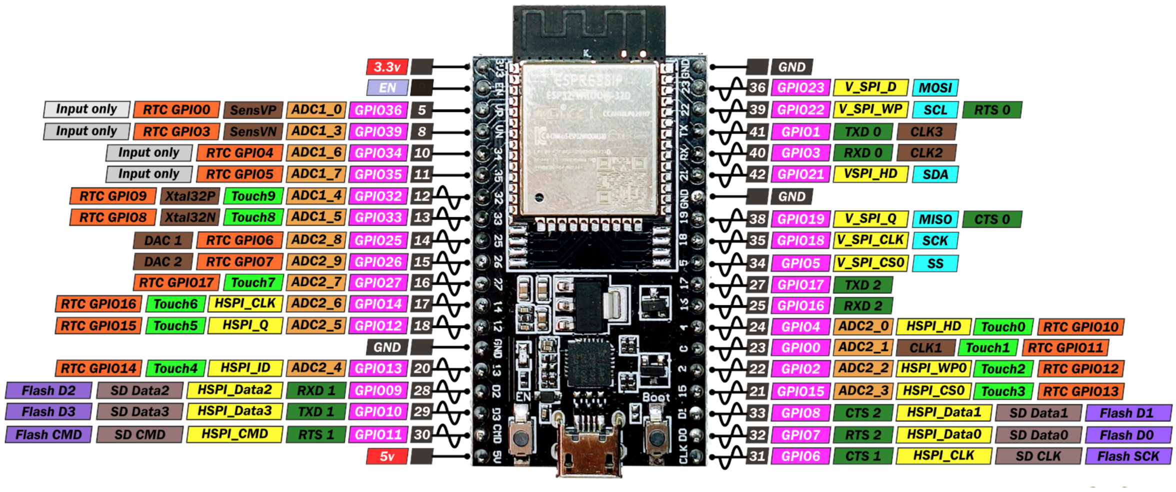



**Figure 2:** Pinout diagram of Node MCU V4

3. <u>HW-131 BreadBoard Power Supply:</u>

HW - 131 is a special power module for breadboard , compatible with 5V and 3.3V. Apply to breadboard, useful to arduino projects. The input voltage supplied through USB power supply or DC. The output voltage can be switched between 3.3v and 5v.Fluctuation two road independent control can switch over to 0 V, 3.3 V, 5 V. HW - 131 also helps protect the circuits from short-circuit protection and overcurrent protection.It is also helpful to check whether the leds are working or not. It provides the voltage or power to electronic circuits without need for an external power source.

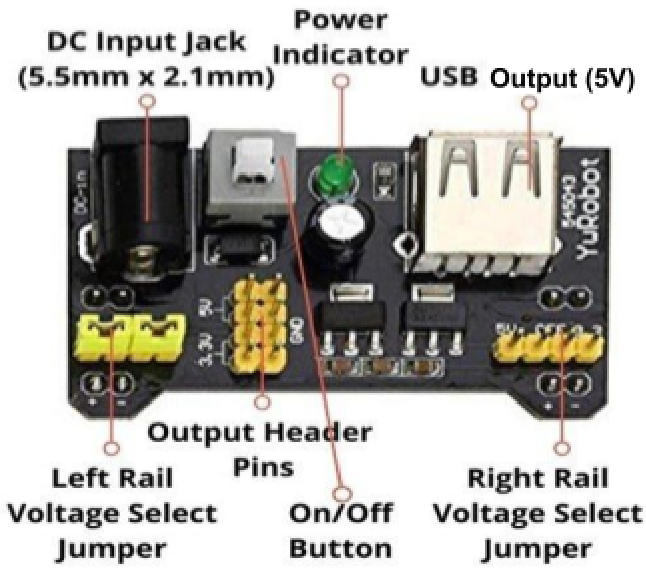



**Figure 3:** HW131 BreadBoard Power Supply

## System Architecture:

The solution proposed comprises a centralised microprocessor board handling all types of inputs and outputs. The ESP-8266 (commonly referred as Node MCU) is the central hub here.

The ESP-8266 board contains a Wifi chipset - which is used here to host the home server locally on the network and send and receive commands from the client through HTTP. The PIR Sensors (model no. - HC-SR501), used as motion sensors, are connected to the Node MCU to provide inputs about human movement within the range of detection. All sensors used in the model are calibrated to consistently detect motion in a given range by dialing the sensitivity and delay potentiometers. The entire system is powered by a 5V DC power supply - in this case the HW-131 breadboard power supply.

The Node MCU board is connected to an access point through which multiple clients can connect to it using the IP address allocated to it by the router. Once a client connects to the server, a HTML page is rendered containing the relevant buttons to toggle the appliances on and off. Another button is present to toggle the master control to the server. If this is toggled on, the inputs from the PIR sensors are ignored, and the appliances will only respond to inputs from the client through the server. Otherwise, the board will default back to the motion sensors for inputs. All the code for the board was written using the Arduino IDE

## Implementation:

A model of dimensions 40 cm x 40 cm x 40 cm has been created to showcase the system. The model is made of 6 mm MDF board, with 2 floors. It consists of a staircase from the ground level to the first floor, and a room with an open roof, a door and a window on the first floor.

A few images of the model are attached below
The model has two PIR sensors. The location and the function of the PIR sensors are as below:

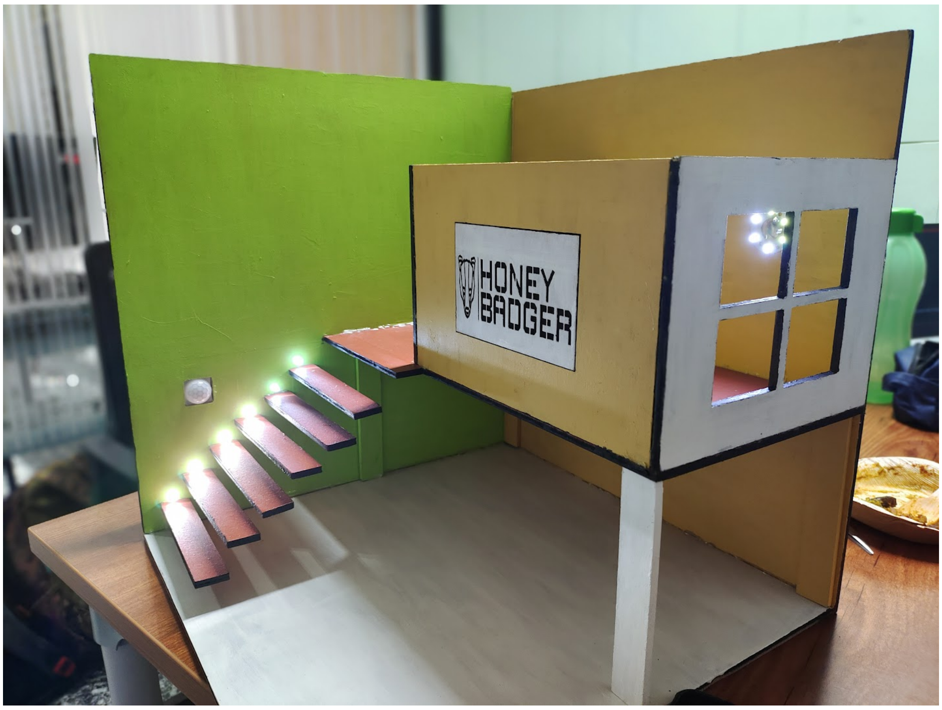
1. Stairs:

   The first PIR sensor is placed on the wall beside the stairs such that any motion detected within the set range of the sensors (1 m) will trigger the 6 LEDs on 6 stairs respectively to light up sequentially. The LEDs light up with a specific delay, hence the sequential lighting up of the LEDs can be observed. After a set time duration the LEDs will turn off if no new input is given by the PIR sensor and the LED on the first stair is switched on (default condition).
   The input by this PIR sensor will only be considered unless the master switch on the server side is turned off. If the master switch is turned on the motion detection by the PIR sensor will not be considered and the server can control the LEDs like any regular manual switch at home and turn it on or off. Once the server switches the LEDs on the LEDs light up sequentially only once and then remain to stay lit until turned off by the server.

2. Room:

    The second PIR sensor is placed on the entrance wall of the room such that on entering the room, motion will be detected and will trigger the lights on. Any motion within the room would also trigger the lights to stay lit unless no motion is detected.

    The input by this PIR sensor will only be considered unless the master switch on the server side is turned off. If the master switch is turned on the motion detection by the PIR sensor will not be considered and the server can control the LED like any regular manual switch at home and turn it on or off. Once the server switches the LED on the LED lights up and then remains to stay lit until turned off by the server.




The Node MCU is mounted behind the model and connections are made as shown below in the circuit diagram:

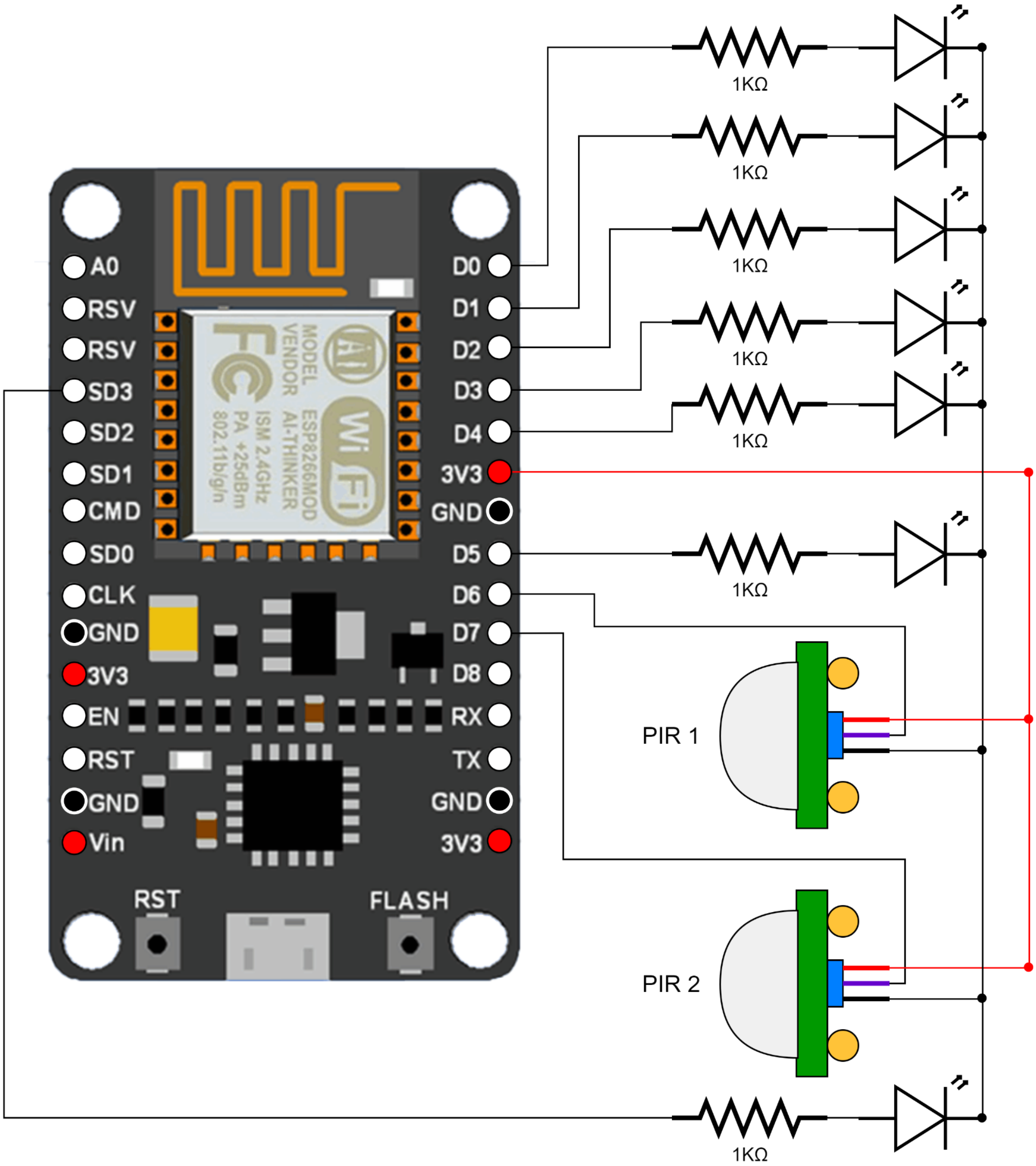



**Figure 4:** Circuit diagram

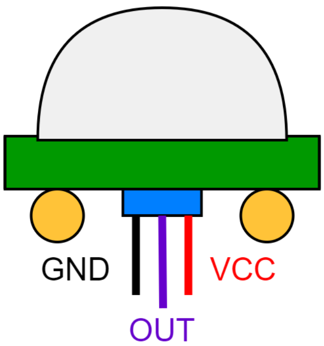



**Figure 5:** PIR Sensor Pinout

## Test Plan And Results:

The test plan and its results can be divided into two scenarios:

A. Home server control:

When the Home server control (Master switch) is turned on, the input by the PIR sensor is ignored. Here, on the server two buttons are programmed - which control the lights on the stairs and the light in the room. Both the buttons can be turned on and off one after the other and simultaneously like any other switch that we use in our day-to-day life at home. When the switch for the lights on the staircase is toggled on, the lights on the stairs turn on sequentially and continue to be lit until toggled off. When the switch for the lights in the room is toggled on, it turns on and stays lit till the lights are prompted to toggle off.

B. Motion detection using PIR sensor

When the Home server control (Master switch) is turned off, the input by the PIR sensor is considered. Here, on detection of motion and infrared radiation emitted by the body(within the set range of the sensor), the lights on the stairs turn on sequentially and continue to turn on sequentially till no motion is detected. Similarly, lights will turn on in the room on detection of motion by infrared radiation emitted by the body(within the set range of the sensor) and continue to stay lit. Once no motion is detected and the wait (delay) time is surpassed the lights will turn off.

## Analysis of Test Results:

Most test cases result in the expected functioning of the system. However, certain exceptions were noted down. On motion being sensed next to the staircase, motion in the room is not taken into account at that instance since there is a delay in turning each of the 6 LED’s on in the staircase. This is however not a real world test case, and if the LED’s are programmed to be turned on at the same instance, this exception wouldn’t occur.

Another major exception was the false triggering of the PIR sensors. These sensors have a minimum range of approximately 1 metre which is over twice the maximum dimensions of the model (which is 0.4 m or 40 cm). Human activity within 1m of the sensor, such as people walking near the model, people shaking their heads or hands above the model, etc. cause the sensors to be triggered. In the real world, this would be fine since most rooms and corridors where these sensors would be installed would be greater than 1 or 2 metres in any given direction of detection.

## Applications and Future scope:

Casa Connect can be used for a wide range of applications from personal homes , hotels, dorms and small warehouses. As our design works on PIR sensors, the amount of footfall on the monitored area will result in slight variations in the working of the system.

To further enhance its performance, several steps can be taken. Firstly, employing advanced sensors instead of PIR sensors can improve accuracy and detection capabilities. Secondly, calibrating the sensitivity and delay settings based on the expected footfall can optimise the system's response. Ensuring a secure connection between the client and server is crucial for data integrity and privacy. Additionally, minimising the connections between the sensors and the main board can enhance reliability and reduce potential points of failure. Improving the code implementation can enhance efficiency and add new functionalities. Lastly, implementing a better and more reliable power supply system can ensure uninterrupted operation. By implementing these improvements, CasaConnect can offer even greater functionality and performance.

## Conclusion:

This project was a great learning experience on how to divide tasks among teammates and collaborate with each other to get a fruitful result. From using advanced laser cutting technologies to writing code keeping in mind the size and simplicity of the Node MCU, this was a successful learning experience with a positive outcome and result. CasaConnect will be worked upon to more reliably and efficiently automate homes and other spaces.

## **Bibliography**: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