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# Smart Home Automation using Machine Learning Algorithm

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**ABSTRACT:** Smart home automation has emerged as a transformative technology capable of enhancing comfort, security, and energy efficiency in modern living spaces. Traditional automated systems mainly use manual switches, simple sensors or set times, which makes it hard for them to adjust to changes happening around them in real time. With advancements in artificial intelligence and computer vision, home automation systems can now become more intelligent and responsive. This project introduces a vision based smart home automation system using OpenCV image processing techniques to detect human presence and automatically control household appliances. The primary aim of the system is to eliminate manual operation of devices while optimizing energy consumption. The proposed system uses a camera to continuously capture live video input from the environment. The captured frames are processed using techniques such as grayscale conversion, noise filtering, and feature extraction to improve detection accuracy. Human (person) detection is performed using OpenCV based models such as Haar Cascades, or lightweight deep learning methods like MobileNet SSD, enabling reliable detection even under different lighting conditions. When a person is detected, the system sends a signal to the ESP32 microcontroller through serial communication. The ESP32 then activates the relay module, which turns ON the fan and light automatically. At the same time, an I2C LCD display shows the status message “Person Detected Fan & Light ON”. When no person is detected, the ESP32 deactivates the relay, turning OFF the fan and light, and the LCD displays “No Person System OFF”. This ensures efficient energy usage and provides a fully automatic, hands free smart home control system.

## I. INTRODUCTION

The rapid growth of digital technologies in recent years has significantly transformed the concept of home automation. Homes are no longer limited to traditional manually operated switches or simple electronic circuits; instead, they are evolving into intelligent, interconnected, and automated environments. Smart home automation refers to the use of advanced technologies to control household appliances, monitor environmental conditions, ensure security, and provide comfort with minimal human intervention. With the increasing demand for convenience, safety, and energy efficiency, the role of smart automation systems has expanded from luxury to necessity in modern living spaces. The integration of artificial intelligence (AI), machine learning (ML), and computer vision has opened new possibilities, allowing home systems to make autonomous decisions based on real-time human activity and environmental conditions. In conventional home automation systems, devices are controlled either manually or through sensors such as PIR motion sensors, timers, or remote controllers. Although these systems are useful, they suffer from several limitations. They cannot accurately distinguish between different users, interpret complex scenes, or adapt to changing conditions such as lighting variations or occasional movement from pets. These constraints make traditional automation unsuitable for applications requiring high reliability, personalized control, and intelligent decision-making.

## II. OBJECTIVES

- The main objective of this project is to design and implement an intelligent smart home automation system that leverages machine learning algorithms and computer vision techniques to autonomously monitor human presence and control home appliances without manual intervention.
- This project aims to replace conventional sensor-based automation with a more accurate and reliable vision-based approach that can interpret real-time environmental conditions using a camera and OpenCV. By integrating

Python-based image processing with an Arduino-controlled relay system, the system intends to achieve seamless coordination between software intelligence and hardware actuation.

- Another important objective is to demonstrate how machine learning can enhance decision-making in home automation by enabling the system to distinguish between different scenarios, reduce false activations, and adapt to varying lighting or movement conditions.
- The project also seeks to improve energy efficiency by ensuring that devices such as lights and fans operate only when required, thereby reducing unnecessary power consumption.
- Furthermore, this work aims to create a user-friendly, cost-effective prototype that can be expanded to include advanced features such as face recognition, gesture-based control, intrusion detection, and remote monitoring.
- Ultimately, the objective is to develop a modern smart home system that enhances convenience, safety, and efficiency through the intelligent integration of machine learning, computer vision, and embedded hardware.

#### **IV. LITERATURE SURVEY**

##### **1. Smith et al., 2020 – Machine Learning for Smart Home Automation**

This

study emphasizes the use of machine learning algorithms, such as decision trees and support vector machines, to predict human activity in a home environment. The system collects real-time sensor data and analyzes patterns to automate the control of electrical appliances. The authors highlight that predictive models can reduce energy consumption and provide a responsive environment for the user.

**2. Wang, 2018 – Human Detection Using Computer Vision** Computer vision techniques, including background subtraction and Haar cascades, allow real-time detection of human presence in indoor environments. The research demonstrates that integrating cameras with embedded controllers can effectively switch devices on or off based on occupancy, minimizing unnecessary energy usage.

##### **3. A. Kumar & S. Ravi, 2022 – IoT Based Smart Home Automation System**

This research presents an IoT-enabled smart home automation system using ESP32 and Wi-Fi communication. The system allows users to monitor and control household appliances remotely through a mobile application or web interface. Sensors such as temperature, humidity, and motion sensors were integrated to automate device operation intelligently. The study highlights the advantages of low-cost implementation, energy efficiency, and real-time monitoring for modern smart homes.

##### **4. P. Sharma et al., 2021 – Energy Efficient Smart Lighting System**

The authors developed a smart lighting system using motion sensors and light intensity sensors to reduce electricity consumption. The system automatically turns lights ON when human movement is detected and switches them OFF when no activity is present. Experimental results showed significant energy savings in offices and residential buildings. The research demonstrates how automation can contribute to sustainable energy management.

#### **V. EXISTING & PROPOSED SYSTEM**

##### **5.1 EXISTING SYSTEM**

Home automation has become an important part of modern smart living, aiming to improve convenience, security, and energy efficiency in residential environments. Traditional home automation systems mainly depend on manual control, timer-based operations, or simple sensor mechanisms to manage electrical appliances such as lights, fans, and security devices. In many existing systems, appliances are controlled using physical switches, remote controls, or basic motion detection sensors like Passive Infrared (PIR) sensors. Although these methods provide a certain level of automation, they are limited in intelligence and adaptability. For example, a motion sensor can detect movement and turn on a light, but it cannot identify who the person is or determine whether the appliance should remain active. As a result, devices may continue operating unnecessarily, leading to increased energy consumption and reduced efficiency. In addition, traditional systems offer limited security because they cannot verify the identity of users accessing the environment. Most existing automation systems also rely on predefined schedules or fixed conditions, which do not adapt to user behavior or real-time environmental changes. A timer-based lighting system may activate lights at a specific time even when no person is present in the room, causing unnecessary power usage. Similarly, remote-controlled systems still require constant human interaction, which reduces the effectiveness of automation. To overcome these limitations, the

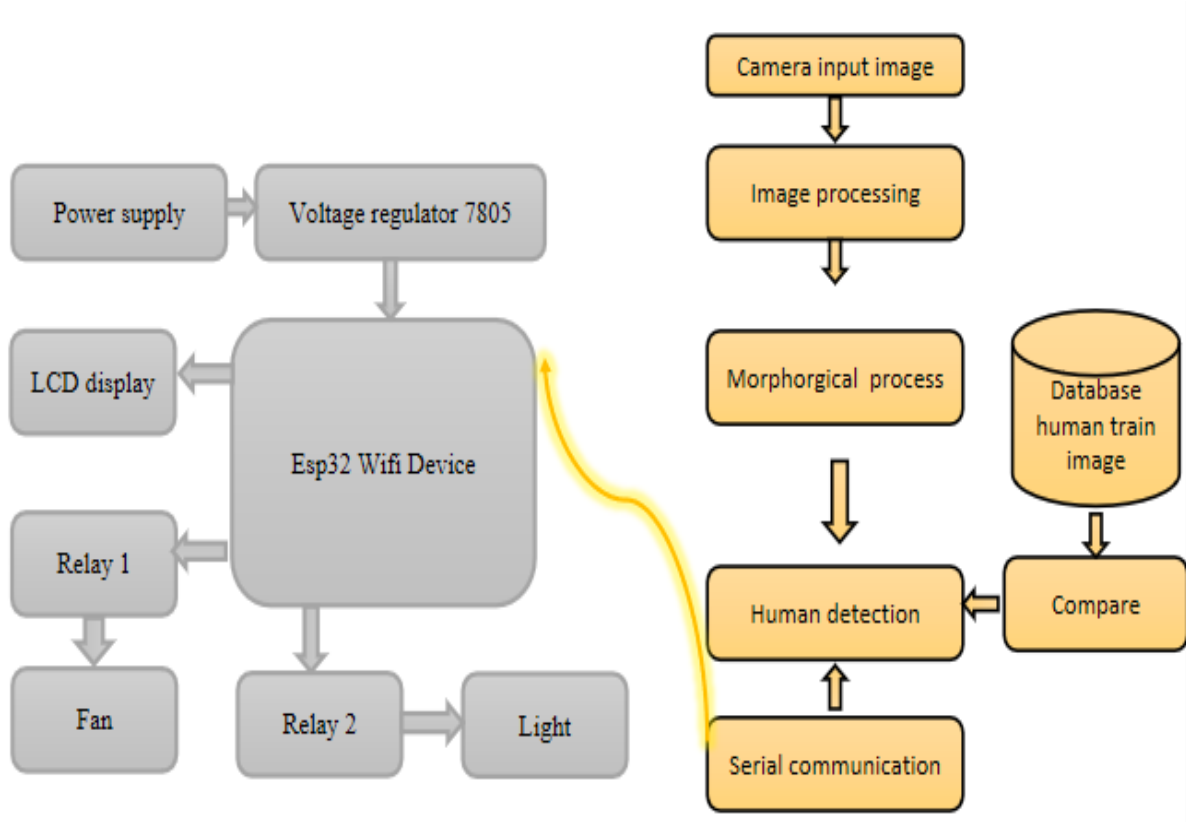
proposed system integrates machine learning, computer vision, and embedded hardware technologies to create an intelligent and adaptive home automation system.

**5.2 PROPOSED SYSTEM**

The proposed system aims to overcome the limitations of conventional home automation by integrating machine learning, computer vision, and embedded systems to create a smart, intelligent, and responsive home environment. Unlike traditional systems that rely on manual switching, timers, or simple motion sensors, this system is designed to operate automatically based on real-time human activity.

At the core of the system is a camera that captures live video streams, which are processed using Python and OpenCV. Image processing techniques are employed to detect human presence, while machine learning algorithms help in analyzing the captured frames to distinguish humans from other objects and, if required, recognize individuals. This intelligent detection ensures that electrical appliances such as lights, fans, and security devices are only activated when necessary, thereby enhancing energy efficiency and reducing wastage. The hardware architecture of the proposed system consists of an Arduino microcontroller, relay driver circuits, power supply modules, and an LCD display for real-time system monitoring. The Arduino receives commands from the Python application through serial communication, which allows it to control connected electrical loads safely and reliably. The relay modules act as switches that handle high-power devices, ensuring that the microcontroller can operate low-power signals while controlling appliances that operate on higher voltage. The LCD display provides visual feedback about the status of the system, such as which devices are currently active, the presence of people in various rooms, and system alerts. This combination of hardware and software enables the system to be highly responsive, user-friendly, and secure.

**VI. BLOCK DIAGRAM**



**Fig No: 1 Block diagram**

## VII. HARDWARE REQUIREMENTS

### 1. POWER SUPPLY

12V DC power supplies are among the most commonly used power supplies today. Typically, a 12V DC output is derived from a 120V AC or 240V AC input through a combination of transformers, diodes, and transistors. 12V power supplies are available in two main types: regulated and unregulated.



Fig No: 2 Power Supply

### 2. IC 7805 REGULATOR

All voltage sources cannot provide a fixed output due to fluctuations in the circuit. To achieve a constant and steady output, voltage regulators are used. The integrated circuits used for voltage regulation are called voltage regulator ICs. Here, we will discuss the IC 7805. The voltage regulator IC 7805 is a member of the 78xx series of voltage regulator ICs.

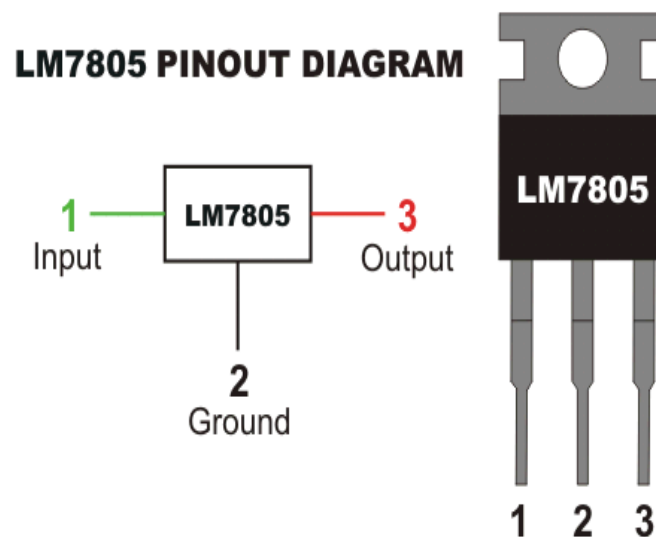


Fig No: 3 IC 7805 REGULATOR

### 3. ESP32

The ESP32 is a powerful, low-cost, and energy-efficient System on Chip (SoC) developed by Espressif Systems. It is widely used in Internet of Things (IoT) applications due to its dual-core processor, built-in Wi-Fi and Bluetooth connectivity, and rich peripheral interfaces. The ESP32 has become one of the most preferred modules for modern embedded projects requiring wireless data communication, cloud connectivity, and remote monitoring.



Fig No: 4 ESP32

#### 4. LCD DISPLAY

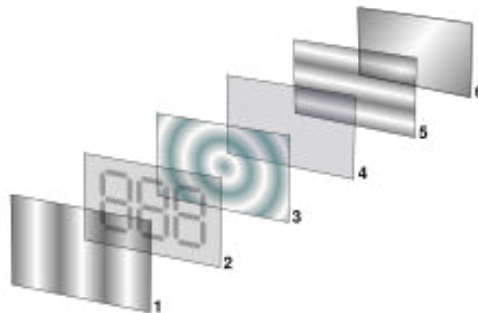


Fig no 5: Liquid crystal display

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

#### RELAY

The relay function can be better understood by explaining the following diagram given below.

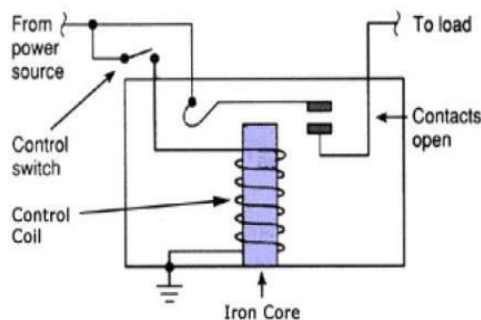


Fig no:6 Relay design

The diagram shows an inner section diagram of a relay. An iron core is surrounded by a control coil. As shown, the power source is given to the electromagnet through a control switch and through contacts to the load. When current starts flowing through the control coil, the electromagnet starts energizing and thus intensifies the magnetic field. Thus, the upper contact arm starts to be attracted to the lower fixed arm and thus closes the contacts causing a short circuit for the power to the load.

## 6. FAN

The exhaust fan is an essential component of the solar drying system, used to maintain proper airflow inside the drying chamber. It helps in removing humid air generated during the drying process and replaces it with fresh air, thereby improving drying efficiency. Based on real-time data obtained from the ESP32 automatically activates or deactivates the fan. When the humidity level inside the chamber increases beyond a predefined limit, the fan is turned ON to expel moist air. Once the humidity level reduces, the fan is turned OFF to conserve energy. This automated operation ensures uniform drying, prevents moisture accumulation, and enhances the overall performance of the drying system.



Fig No: 7 FAN

## 7 .LED Bulbs:



FIG NO: 8 LED Bulb

LED bulbs are the future of indoor and outdoor lightening. These bulbs are among the best replacements of the incandescent lights. The 10-Watt LED bulbs bring with them the major science and technology advancements, using the revolutionary light-emitting diodes (LED). Although the cost is slightly higher than CLF and incandescent lights, the long lifespan and energy efficiency makes LED lights much more cost-effective.

### VIII. RESULT

The developed vision-based smart home automation system successfully performs real-time human detection and automatic control of appliances using OpenCV and ESP32. The system captures continuous video input through a camera and processes the frames using image processing techniques such as grayscale conversion, noise filtering, and feature extraction. Person detection is carried out using OpenCV models like Haar Cascade or HOG-SVM, which provide reliable detection under different lighting conditions. When a person is detected, the system sends a command through serial communication to the ESP32 microcontroller. The ESP32 then activates the relay module, turning ON the fan and light automatically. At the same time, the I2C LCD display shows the message “Person Detected – Fan & Light ON,” providing real-time system feedback. When no person is detected, the system sends another command to the ESP32, which turns OFF the relay, thereby switching OFF the fan and light. The LCD updates the status to “No Person – System OFF.” The system demonstrates fast response, stable communication, and efficient operation. Overall, it reduces unnecessary power consumption and ensures a smooth, automatic control mechanism without human intervention.

### IX. CONCLUSION

In conclusion, This project presents an intelligent and efficient smart home automation system using OpenCV and ESP32. By integrating computer vision with embedded system control, the system eliminates the need for manual switching of appliances and improves overall energy efficiency. The person detection mechanism ensures that electrical devices operate only when required, reducing electricity wastage and enhancing convenience. The use of serial communication enables reliable and real-time interaction between the image processing unit and the ESP32 microcontroller. Additionally, the LCD display provides clear visual feedback about the system status, making it user-friendly and easy to monitor. The system is cost-effective, scalable, and suitable for modern smart home applications. It can be further enhanced by adding IoT features such as remote monitoring, mobile app control, or voice assistant integration. Overall, this project demonstrates a practical and effective approach to building an automated, energy-saving, and intelligent home environment.

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