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SECURE IOT-BASED HOME AUTOMATION WITH REAL-TIME MONITORING USING ESP32-CAM AND GOOGLE ASSISTANT

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Abstract

This project presents an IoT and Google Assistant-based Home Automation System with Surveillance Camera using ESP32-CAM and ESP8266 microcontrollers. The system enables users to remotely monitor and control household appliances through voice commands and internet connectivity. The ESP32-CAM functions as a web server, providing real-time video streaming for home surveillance and security monitoring. The ESP8266 is connected to the Google Assistant through the Blynk/Cayenne/IoT platform (or suitable cloud service), allowing users to control electrical devices using voice commands from smartphones or smart speakers. The system integrates multiple sensors, including the DHT11 temperature and humidity sensor, MQ-7 carbon monoxide gas sensor, and a fire sensor to continuously monitor environmental conditions and detect hazardous situations. Upon detecting abnormal temperature, gas leakage, or fire, the system generates alerts and can automatically activate safety measures.

Three relay modules are used to control a 12V fan, 12V light, and 12V motor. A 5V power supply powers the microcontrollers and sensors, while a 12V supply drives the connected appliances. The combination of IoT technology, voice control, environmental monitoring, and live video streaming provides an efficient, low-cost, and intelligent home automation solution that enhances convenience, safety, energy management, and security.

Keywords: IoT, Home Automation, Google Assistant, ESP32-CAM, ESP8266, DHT11, MQ-7, Fire Sensor, Relay Control, Smart Home, Surveillance System.

I.INTRODUCTION

1.1 Background

The rapid growth of the Internet of Things (IoT) has transformed traditional homes into intelligent environments capable of monitoring and controlling various appliances remotely through the Internet. IoT enables physical devices such as sensors, controllers, cameras, and household appliances to communicate with each other and exchange data over wireless networks. This technology has significantly improved convenience, energy efficiency, security, and safety in modern homes. IoT-based systems allow users to monitor and control devices from anywhere using smartphones, web applications, or voice assistants.

Home automation is one of the most popular applications of IoT technology. A home automation system enables automatic or remote control of electrical appliances such as lights, fans, motors, and security devices. Traditional home automation systems often require manual operation or dedicated control panels, whereas IoT-based systems provide real-time monitoring and control through the Internet. The use of low-cost microcontrollers such as the ESP8266 and ESP32 has made smart home solutions affordable and accessible for residential applications.

In recent years, voice-controlled smart homes have gained significant attention due to the availability of intelligent virtual assistants such as Google Assistant. Voice control provides a natural and convenient way for users to interact with household appliances. By integrating Google Assistant with IoT devices, users can operate electrical equipment using simple voice commands, eliminating the need for physical switches or mobile applications. This feature is particularly beneficial for elderly individuals and people with physical disabilities.

Apart from automation, home security has become an essential requirement in modern households. Security cameras, environmental monitoring sensors, and real-time alert systems help protect

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homes from theft, fire accidents, and hazardous gas leakage. The ESP32-CAM module has emerged as a cost-effective solution for surveillance applications due to its built-in camera, Wi-Fi capability, and web server functionality. The module can stream live video through a web browser, enabling homeowners to monitor their premises remotely.

Environmental monitoring is another important aspect of smart home systems. Sensors such as the DHT11, MQ-7, and fire sensor provide real-time information about temperature, humidity, carbon monoxide concentration, and fire hazards. Continuous monitoring of these parameters enhances the safety of residents by providing early warnings and enabling preventive actions. Multisensor-based IoT security systems have demonstrated their effectiveness in detecting abnormal environmental conditions and improving home safety.

This project proposes an IoT and Google Assistant-based Home Automation System with Surveillance Camera using ESP8266 and ESP32-CAM. The system combines appliance control, voice assistance, environmental monitoring, and live video surveillance into a single smart platform. Three relays are used to control a 12V fan, 12V light, and 12V motor, while sensors continuously monitor environmental conditions. The ESP32-CAM provides live video streaming through a web server, allowing users to monitor their homes remotely. The integration of automation and security features makes the proposed system an effective and economical smart home solution.

1.2 Problem Statement

Although modern smart home technologies offer advanced features, many commercial home automation systems are expensive and require specialized hardware and subscription services. Furthermore, some systems focus only on appliance control without providing adequate security monitoring and environmental sensing capabilities.

Many households still rely on manual operation of electrical appliances, which can lead to energy wastage and inconvenience. Additionally, the absence of continuous surveillance and hazard detection systems increases the risk of unauthorized access, fire incidents, and gas leakage.

Therefore, there is a need for a low-cost, integrated, and user-friendly smart home system that combines:

- Remote appliance control
- Voice-based operation using Google Assistant
- Real-time video surveillance
- Environmental monitoring
- Hazard detection and alert generation

This project addresses these challenges by developing a comprehensive IoT-based home automation and security system using ESP8266 and ESP32-CAM.

II.LITERATURE SURVEY

The Internet of Things (IoT) has revolutionized the way people interact with household devices by enabling remote monitoring, automation, and intelligent decision-making. Smart home systems represent one of the most significant applications of IoT technology. These systems integrate sensors, microcontrollers, communication networks, and cloud services to provide users with enhanced comfort, convenience, energy efficiency, and security. In recent years, researchers have developed various home automation solutions using low-cost embedded platforms such as Arduino, ESP8266, Raspberry Pi, and ESP32.

This chapter reviews existing research works related to IoT-based home automation, voice-controlled systems, environmental monitoring, and surveillance systems using ESP32-CAM. The review helps identify the advantages and limitations of current solutions and provides a foundation for the development of the proposed system.

Windesi et al. (2022) developed an IoT-based home automation system using the ESP8266 NodeMCU platform. The system enabled users to remotely control electrical appliances through a smartphone application connected via Wi-Fi. The authors demonstrated that IoT technology can significantly improve convenience and energy management in residential environments. However, the proposed system primarily focused on appliance control and

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lacked advanced security features such as surveillance cameras and hazard detection sensors.

The study concluded that ESP8266 is an economical and efficient platform for implementing smart home applications due to its built-in Wi-Fi capability and low power consumption. The research also highlighted the growing demand for intelligent home automation systems in modern households.

Voice assistants have become increasingly popular in smart home environments due to their ease of use and accessibility. Saha et al. (2023) developed an IoT-based home automation system integrated with Google Home and Google Assistant. Their system allowed users to control household appliances through voice commands using smartphones and smart speakers.

The researchers employed ESP8266 as the primary controller and integrated it with cloud services for communication between the user and appliances. The system demonstrated reliable performance in controlling electrical devices through voice commands. The study highlighted the importance of voice-controlled automation for elderly users and individuals with physical disabilities.

III.EXISTING AND PROPOSED SYSTEM

3.1 Introduction

Smart home technology has become increasingly popular due to advancements in the Internet of Things (IoT), wireless communication, and embedded systems. Various home automation systems have been developed to improve convenience, security, and energy efficiency. However, many existing systems suffer from limitations such as high cost, limited functionality, lack of security monitoring, and dependence on proprietary hardware. This chapter discusses the existing home automation systems, their disadvantages, the proposed IoT and Google Assistant-based home automation system with surveillance camera, and the advantages offered by the proposed solution.

3.2 Existing System

Traditional home automation systems are designed to control household appliances such as lights, fans, and motors using wired or wireless communication methods. Most systems utilize mobile applications, Bluetooth modules, GSM technology, or Wi-Fi-based control mechanisms.

Some existing smart home systems employ microcontrollers such as Arduino, Raspberry Pi, or ESP8266 to automate appliances through smartphone applications. Other advanced systems integrate voice assistants like Google Assistant or Amazon Alexa for voice-based control.

Similarly, separate surveillance systems using CCTV cameras or IP cameras are deployed to monitor residential premises. Environmental monitoring systems are also available for detecting temperature changes, gas leakage, and fire hazards. However, these systems are often implemented independently rather than as a unified platform.

3.4 Proposed System

The proposed project is an IoT and Google Assistant-Based Home Automation System with Surveillance Camera developed using ESP8266 and ESP32-CAM microcontrollers.

The system integrates appliance control, environmental monitoring, hazard detection, voice control, and live video surveillance into a single platform.

The ESP8266 acts as the primary controller for appliance automation and communication with Google Assistant through an IoT platform. Users can control appliances using voice commands or a smartphone application.

The ESP32-CAM functions as a web server and provides real-time video streaming for home surveillance.

The system incorporates the following sensors:

- DHT11 Sensor for temperature and humidity monitoring.
- MQ-7 Sensor for carbon monoxide gas detection.
- Fire Sensor for fire hazard detection.

Three relay modules are used to control:

- 12V Fan
- 12V Light
- 12V Motor

A 5V power supply powers the microcontrollers and sensors, while a 12V power supply drives the connected appliances.

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Whenever abnormal environmental conditions are detected, the system can generate alerts and activate safety measures.

Comparison Between Existing and Proposed System

Feature	Existing System	Proposed System
Appliance Control	Available	Available
Google Assistant Control	Limited	Available
Live Video Surveillance	Separate System	Integrated
Temperature Monitoring	Limited	Available
Gas Detection	Not Available	Available
Fire Detection	Not Available	Available
Remote Monitoring	Partial	Complete
Cost	High	Low
Ease of Use	Moderate	High
System Integration	Low	High

IV.HARDWARE

ESP8266 WIFI

The **ESP8266** is a low-cost Wi-Fi microchip with full TCP/IP stack and microcontroller capability produced by Shanghai-based Chinese manufacturer, Espressif Systems.[1]

The chip first came to the attention of western makers in August 2014 with the **ESP-01** module, made by a third-party manufacturer, Ai-Thinker. This small module allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections using Hayes-style commands. However, at the time there was almost no English-language documentation on the chip and the commands it accepted.[2] The very low price and the fact that there were very few external components on the module which suggested that it could eventually be very inexpensive in volume, attracted many hackers to explore the module, chip, and the software on it, as well as to translate the Chinese documentation.[3]

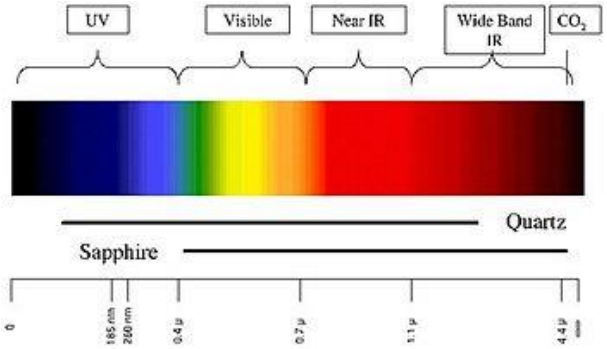
The **ESP8285** is an ESP8266 with 1 MiB of built-in flash, allowing for single-chip devices capable of connecting to Wi-Fi.[4]

Fig: ESP8266

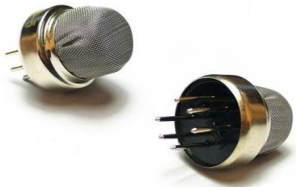
FIRE(FLAME) SENSOR

A **flame detector** is a sensor designed to detect and respond to the presence of a flame or fire, allowing **flame detection**. Responses to a detected flame depend on the installation, but can include sounding an alarm, deactivating a fuel line (such as a propane or a natural gas line), and activating a fire suppression system. When used in applications such as industrial furnaces, their role is to provide confirmation that the furnace is working properly; in these cases they take no direct action beyond notifying the operator or control system. A flame detector can often respond faster and more accurately than a smoke or heat detector due to the mechanisms it uses to detect the flame.

Optical flame detectors



MQ2- SENSOR



MQ2 flammable gas and smoke sensor detects the concentrations of combustible gas in the air and outputs its reading as an analog voltage. The

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sensor can measure concentrations of flammable gas of 300 to 10,000 ppm. The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.

Connecting five volts across the heating (H) pins keeps the sensor hot enough to function correctly. Connecting five volts at either the A or B pins causes the sensor to emit an analog voltage on the other pins. A resistive load between the output pins and ground sets the sensitivity of the detector. Please note that the picture in the datasheet for the top configuration is wrong. Both configurations have the same pin out consistent with the bottom configuration. The resistive load should be calibrated for your particular application using the equations in the datasheet, but a good starting value for the resistor is 20 kΩ.

DHT11 Sensor

Humidity is the measure of water vapour present in the air. The level of humidity in air affects various physical, chemical and biological processes. In industrial applications, humidity can affect the business cost of the products, health and safety of the employees. So, in semiconductor industries and control system industries measurement of humidity is very important. Humidity measurement determines the amount of moisture present in the gas that can be a mixture of water vapour, nitrogen, argon or pure gas etc… Humidity sensors are of two types based on their measurement units. They are a relative humidity sensor and Absolute humidity sensor. DHT11 is a digital temperature and humidity sensor.

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RELAYS

We know that most of the high end industrial application devices have relays for their effective working. Relays are simple switches which are operated both electrically and mechanically. Relays consist of a n electromagnet and also a set of contacts. The switching mechanism is carried out with the help of the electromagnet. There are also other operating principles for its working. But they differ according to their applications. Most of the devices have the application of relays.

DC FAN:

A **fan** is a powered machine used to create flow within a fluid, typically a gas such as air. A fan consists of a rotating arrangement of vanes or blades which act on the air. The rotating assembly of blades and hub is known as an impeller, a rotor, or a runner. Usually, it is contained within some form of housing or case.[1] This may direct the airflow or increase safety by preventing objects from contacting the fan blades. Most fans are powered by electric motors, but other sources of power may be used, including hydraulic motors, handcranks, internal combustion engines, and solar power.

Mechanically, a fan can be any revolving vane or vanes used for producing currents of air. Fans produce air flows with high volume and low pressure(although higher than ambient pressure), as opposed to compressors which produce high pressures at a comparatively low volume. A fan blade will often rotate when exposed to an air fluid stream, and devices that take advantage of this, such as anemometers and wind turbines, often have designs similar to that of a fan.

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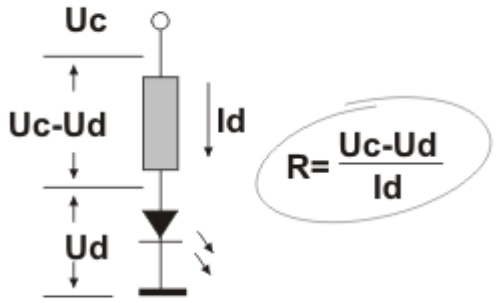
Light-emitting diode (LED)

Light-emitting diodes are elements for light signalization in electronics. They are manufactured in different shapes, colors and sizes. For their low price, low consumption and simple use, they have almost completely pushed aside other light sources-bulbs at first place. They perform similar to common diodes with the difference that they emit light when current flows through them.



V.BLOCK DIAGRAM AND WORKING

5.1 Introduction

The proposed system is an IoT and Google Assistant-Based Home Automation System with Surveillance Camera that integrates appliance control, environmental monitoring, hazard detection, and live video surveillance into a single platform. The system uses ESP8266 as the main controller for automation and ESP32-CAM for video streaming. Users can control appliances through Google Assistant and monitor environmental conditions remotely through the Internet.

The system incorporates sensors such as DHT11, MQ-7, and Fire Sensor to monitor temperature, humidity, carbon monoxide gas, and fire hazards. Relay modules are used to control household appliances including a 12V fan, 12V light, and 12V motor.

5.2 Block Diagram

IoT and Google Assistant-Based Home Automation System

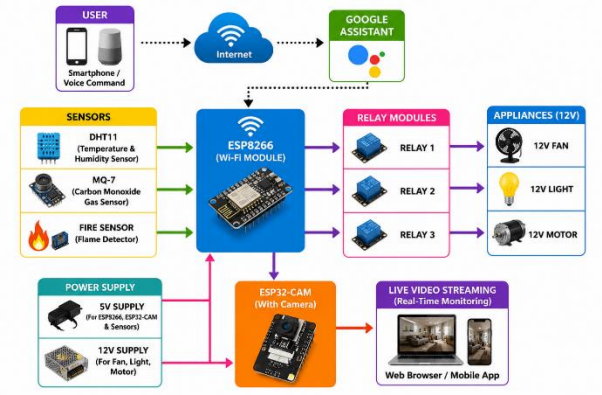


Fig: Block diagram

5.3 Components Used

Hardware Components

S.No	Component	Quantity
1	ESP8266 NodeMCU	1
2	ESP32-CAM	1
3	DHT11 Sensor	1
4	MQ-7 Gas Sensor	1
5	Fire Sensor	1
6	3-Channel Relay Module	1
7	12V Fan	1
8	12V Light	1
9	12V Motor	1
10	5V Power Supply	1
11	12V Power Supply	1

5.4 Working of the System

The working of the proposed system is divided into four major sections:

5.4.1 Voice-Controlled Home Automation

The user gives voice commands using Google Assistant through a smartphone or smart speaker. The command is transmitted through the Internet to the Cayenne IoT cloud platform. The ESP8266 receives the command via Wi-Fi and processes it. Based on the received command:

- Relay 1 controls the 12V Fan.
- Relay 2 controls the 12V Light.
- Relay 3 controls the 12V Motor.

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The appliance is switched ON or OFF according to the user command.

5.4.2 Environmental Monitoring

The DHT11 sensor continuously measures:

- Temperature
- Humidity

The measured values are transmitted to the ESP8266 and uploaded to the IoT dashboard for remote monitoring.

Users can monitor environmental conditions from anywhere through the Internet.

5.4.3 Gas and Fire Detection

The MQ-7 sensor continuously monitors the concentration of carbon monoxide gas in the surrounding environment.

If the gas concentration exceeds the predefined threshold:

- The ESP8266 generates an alert.
- Warning notifications can be sent through the IoT platform.

Similarly, the fire sensor continuously detects the presence of flames.

When fire is detected:

- Emergency alerts are generated.
- Safety measures can be activated automatically.

These features improve home safety and reduce the risk of accidents.

5.4.4 Video Surveillance System

The ESP32-CAM module operates as a standalone web server.

Its functions include:

- Capturing live images.
- Streaming real-time video.
- Providing remote surveillance through a web browser.

The user can access the camera feed from any device connected to the same network or through configured remote access.

The surveillance feature improves home security by allowing continuous monitoring of the premises.

VI.CONCLUSION AND FUTURE SCOPE

6.1 Conclusion

The IoT and Google Assistant-Based Home Automation System with Surveillance Camera has been successfully designed and implemented using ESP8266, ESP32-CAM, DHT11, MQ-7, Fire Sensor, and relay modules. The system integrates home automation, environmental monitoring, hazard detection, and real-time video surveillance into a single smart platform.

The ESP8266 serves as the main controller for appliance automation and communication with the IoT cloud platform, while the ESP32-CAM provides live video streaming for remote surveillance. The integration of Google Assistant enables users to control household appliances such as a fan, light, and motor through simple voice commands. This feature improves user convenience and accessibility, especially for elderly and physically challenged individuals.

The DHT11 sensor continuously monitors temperature and humidity levels, whereas the MQ-7 sensor detects harmful carbon monoxide gas and the fire sensor identifies fire hazards. These safety features help prevent accidents by providing early warning alerts. The relay module allows efficient control of electrical appliances through the Internet.

The developed system offers several advantages, including low cost, easy installation, remote accessibility, enhanced security, and energy-efficient operation. By combining automation, monitoring, and surveillance functionalities, the proposed system provides a practical and reliable solution for modern smart homes.

Overall, the project demonstrates the effective application of IoT technology in creating an intelligent home environment that enhances comfort, safety, and security while reducing manual effort.

6.2 Future Scope

Although the proposed system successfully achieves its objectives, several improvements can be made in the future to enhance its functionality and performance.

1. Mobile Application Development

A dedicated Android or iOS application can be developed to provide a more user-friendly interface for monitoring and controlling appliances.

2. Artificial Intelligence Integration

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Artificial Intelligence (AI) and Machine Learning algorithms can be incorporated to analyze user behavior and automatically control appliances based on usage patterns.

3. Face Recognition System

The ESP32-CAM can be upgraded with facial recognition capabilities to identify authorized users and improve home security.

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