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IOT BASED SMART HOME AUTOMATION AND MONITORING SYSTEM

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Abstract

The concept of a smart home is becoming increasingly popular these days. It reduces the amount of physical labor required. In a traditional home, we cannot monitor the electrical appliances, environmental conditions, home security, and cannot control them remotely. Typical residential systems cannot automatically change a systems state in response to a specific scenario. However, this study proposes an IoT-based smart home automation system that works in different modules to automate the entire home. In one module, the system determines the human movement inside the room by using a IR sensor and detects the light level using an LDR sensor. The light level will be adjusted based on the output of the IR sensor. Also, the system operates the fans and heater based on the home temperature and humidity by using an AM2301 sensor. In another module, a flame sensor aids the detection of fire, MQ-135 sensor measures the air quality. In case of fire is detected in the home, the system will also alert the users instantly. To control everything remotely, a mobile application (Blynk App) is used. Converting to a smart home, it can provide security, energy efficiency, and the ability to manage every existing home appliance from a centralized location or remotely. As a result, the system focuses on generating the most excellent possible environmental conditions while requiring the least amount of human effort possible. Beyond everything, it helps in saving time in every manner conceivable.

Keywords: IoT, NodeMCU, Smart Home, Blynk App.

Introduction

A smart house is a contemporary home where the appliances and electronics can be managed remotely by the owner, often through a smartphone app. Smart home goods and equipment may also be connected to other smart devices, making smart home technology incredibly easy and convenient. As technology progresses, revenue in the smart home market is likely to climb. According to experts and smart home facts, the rising emphasis on security and wireless innovation and development in the Internet of things (IoT) will move the market forward at an astonishing rate. According to estimates from smart appliances on sales and income in the smart technology homeware industry, the US business is predicted to rise at a 14.3 percent annual pace

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from 2020 to 2024, hitting $47.12 billion (Cvetkovska, 2022). More excellent safety via appliance and lighting management enhanced security through motion detectors, increased convenience through temperature control, and saved time, power, and money are just a few of the benefits of home automation systems. A home automation system should provide a user-friendly interface so that household appliances may be set up, monitored, and controlled quickly and easily. In addition, to utilize the full potential of wireless technology, the automation system must be quick enough and offer a dependable connection with an adequate data rate and communication range. Finally, the system controller should be affordable for the general public to own and justify its usage in home automation. To resolve these design flaws and eliminate the inadequacies of home automation systems, this study presents a combination of physically and remotely operated automation systems. This system detects abnormal activity, movement, light levels, temperature, humidity, and air quality. Users will get an alert message if the system detects a fire. The important contributions of this study are summarized below.

- We primarily use data from several installed sensors throughout the home to automate the functioning of various essential household kinds of equipment such as fans, lights, air conditioners, and heaters. These sensors will be linked to a Node MCU, interpreting the sensor data and operating the relays connected to the appliances.
- We've also implemented the option to send an alert message to the user using the mobile application in case of a fire.
- Finally, we used a simulation platform to demonstrate the performance of the proposed system.

This paper will now be structured as follows. Section two describes the existing home automation systems, and the third section compares the suggested solution to the entire research procedure. Finally, the findings of the experiments are presented in section four. Thus, chapter five brings the paper to a close.

Related Works

Many modern commercial systems for innovative home management are developed, and these systems showed improvement over previous systems tied around traditional or older technologies. In (Jie et al., 2013) authors proposed a system where they develop an IoT-based smart home. The authors used some agents for different interfacing types of home appliances. In their system, they define a controller unit to control the system based on the system owner command. The author (Santoso et al., 2015) suggested a system called Securing IoT for Smart Home Systems. The system consists of some IoT devices connected to the Internet through a home network gateway and shows the output to Mobile Applications. In (Patru et al., 2016) the authors proposed a system to develop a smart home IoT system. The submitted paper mentions that the authors mentioned some sensors to measure some environmental value and sensors connected to the Internet. The authors use a buzzer, light bulb, and motors in the actuator section, which follow the command of the controller board of the system. The authors of the paper (Malche et al., 2017) presented a system based on IoT while building a smart home system. In this system, the authors use a Temperature and Humidity sensor and an Air monitoring sensor to read the environmental value and use window/door controllers, smart appliances, and light to the actuator unit. All devices of that system are connected to the Internet. In (Sivaraman et al., 2015), the authors mentioned a system that controls smart home IoT devices' network-level security and privacy through the Internet. The authors use a network controller, switch, and gateway by which the home devices are connected to the Internet. The system also ensures the security of the devices and data. The research (AlHammadi et al., 2019) focuses on a system that can be operated remotely utilizing light settings and ambient temperature. This paper depicts a smart device that runs on an Edison board and can be customized with additional functions based on the user's preferences. The high-security aspect of MQTT as a transmission medium, the central broker idea, and excellent quality service are all discussed in this article (Al-Kuwari et al., 2018) . This protocol is critical for increasing automation efficiency and creating a user-friendly

interface. Big data indicates too huge data that comes from numerous sensors in IoT-based home automation. Their luminosity, temperature, relative humidity, and air quality are the measured parameters. These characteristics are monitored and communicated the data across the internet to the cloud using some common protocol (Bluetooth, Zigbee, Wi-fi, GSM) that provides the connectivity between the sensor and the central processing unit. In this research (Islam, 2018) , the solar panel is employed for an efficient energy system and an automated cleaning system for it. The referenced paper (Khan et al., 2018) works with ESP8266 and the temperature sensor LM35 to indicate the room temperature and advise the user whether it's required to switch the AC/Fan ON or OFF. Controlling the appliances is done with a remote control that employs IR and Wi-Fi. People who cannot use cell phones may utilize IR controlling system. For the wi-fi control, the system will offer a secure Access point with a specified service set identity. The user will connect the device to SSID with the password and go to the link for the controlling interface. The document (Patru et al., 2016) contains information concerning security and efficiency. The LDR sensor is used for light on/off properly, the keypad is used for the password, and GSM is used for providing an alert message these are all items included to the smart home system. A smart home energy management system is presented in this research. IEEE802.15.4 and ZigBee are sets of communication protocols that don't waste much energy yet deliver real-time data. This study (Paul et al., 2018) employs a communication component as the server for searching and updating databases and obtaining data from a distant distance. The database component is used to interface with the database. Meter database systems make public services accessible to customers. By utilizing this technology, here quantity of utilized power is tracked and minimized. The major purpose of this study (Sagi et al., 2012) is to build and implement an intelligent home management system. The security mechanism comprises of password and RFID verification. The keypad is used for entering passwords and the RFID module is utilized for RFID tag verification. DHT11 is used for measuring the temperature, a Flame sensor is used to detect a flame, and an MQ135 sensor is used to identify gas. The system detects data from various sensors and operates depending on the circumstances of the user. To make the system more versatile, Voice-controlled devices are suggested here. It works with the Bluetooth module which makes all chores simpler. In this study (Singh et al., 2019) , the author focuses on managing home appliances via the internet by utilizing The Blynk app. A humidity sensor is used to monitor the climatic condition of the house. Finally, a PIR sensor will inform the intruders outside the home. A GPS component is utilized to remotely inform intruders.

In this study, we have proposed IoT-based smart home automation and monitoring system using NodeMCU and Blynk App. In the system, different types of sensors are used to collect the environment data and directly linked to the NodeMCU which acts as a controller of the system. The system controls the light (On or Off) to save energy based on both objects' movement by IR sensors and light intensity determined by LDR sensors. Also, based on the information from DHT21 (AM2301) sensors, the system controls the fan (either on or off). The system can also measure the air quality, detect fire inside the room and perform actions immediately for safety and security . The notable feature of the system is controlling and monitoring everything using the smartphone app Blynk. The system is a user-friendly, smart, and low-cost solution that would modernize home automation and monitoring.

System Setup and Architecture

An LDR sensor will be used to detect the light level. The lights will be switched off throughout the day. We may also operate the fans and lights from a distance using a smartphone app (Blynk). An IR sensor detects human movement at night and activates the lights according to the observed light level. An AM2301 temperature and humidity sensor will be used to measure the room temperature and humidity. The fans will turn on if the temperature rises over a particular point and the IR sensor detects movement. The heater is engaged when the temperature falls below a specified threshold and the IR sensor detects movement. To detect fire, we employ a flame sensor. MQ-135 will be used to identify the presence of harmful gasses. The MQ-135 can detect harmful gasses such as CO2 and ammonia (NH3). When this gas or any other type of fire

is detected, certain actuators will take appropriate action to extinguish it or sound a buzzer to inform the owner. In the, we can also view the current humidity and temperature of the room. When there is a presence of hazardous gas or fire, the app will warn you by email or mobile alert. The system architectiure is described at Figure 1 where the different hardware components used in the system are illustrated in Figure 2.

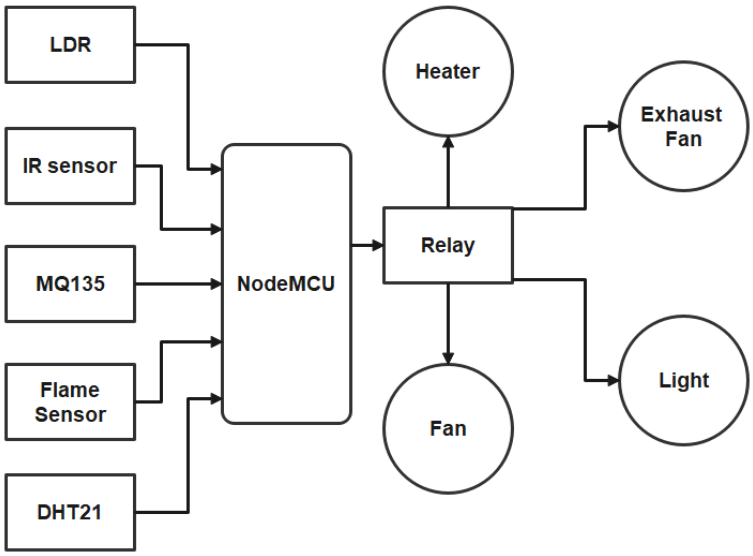


Figure 1. The proposed system's architecture.

Hardware components

Esp8266: Esp8266 is an open-source software and hardware development unit. It contains CPU, RAM, operating system, and wifi module. The difference between Arduino and Esp8266 is Arduino has no wifi module like Esp8266 (Wikipedia, 2015). Our project uses Esp8266 as our central processing unit, and it also communicates with the 'Blynk' IoT platform.

IR sensor: IR sensor measures and detects infrared radiation in the surrounding environment, and it detects movement in a specific range (Wikipedia, 2005). Our system uses IR sensors to detect human movement inside the room.

MQ135: MQ135 is used to measure the presence of bad gas. It can sense harmful gasses like NH3, NOx, Alcohol, Benzene, smoke, and CO2, and it can only sense the presence of these gasses, not the ppm (Components101). In our system, we use MQ135 to identify the presence of bad gases inside our room.

Flame Sensor: Flame sensors usually detect and respond to the flame, and they can give both analog and digital values as output. A flame sensor can detect flame within 760nm to 1100nm wavelength from the light source. They have a speedy response time (Elprocus,2019). Our system uses a flame sensor to detect fire or flame in the house.

AM2301 sensor: The DHT-21 (also known as the AM2301) is a digital-output relative humidity and temperature sensor that is one of the most popular among the DHT temperature sensors. It has a temperature measurement precision of 0.5°C in 0.1°C increments and a relative humidity measurement

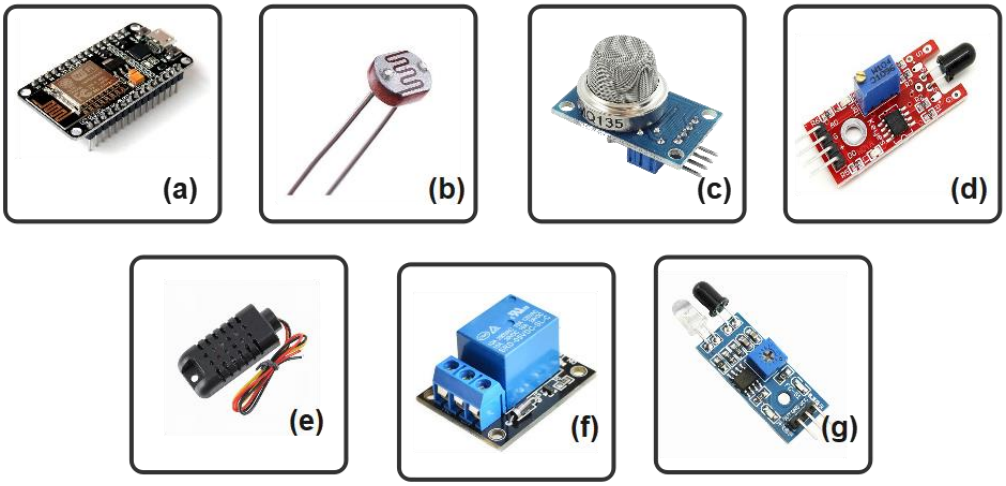


Figure 2. List of Components (a) Esp8266 (b) LDR (c) MQ135 (d) Flame sensor (e) AM2301 (f) Relay (g) IR sensor.

precision of 3%. It may be linked to a microcontroller with only one digital pin since it only has three wires, including power and ground.

Relay: A relay is a switch that generally connects or disconnects two circuits, and it works on the basics of electromagnetic induction. When there is an electrical signal in the relay, it connects or disconnects two circuits (Prasad, 2022). We use a relay to control the lights and fans from our system's 'Blynk' dashboard.

LDR: LDR is a sensor that is sensitive to light. It is made of semiconductor material with high resistance. When light falls on the semiconductors, The resistance of the semiconductor decreases (Electronics notes, n.d.). Our system uses LDR to detect the light levels and switch on and off the lights.

Software components

Arduino IDE: Arduino Software (IDE) is open-source software that makes it easy to write code and upload it to the board. This software can be used with Arduino boards, NodeMCU boards, Etc. In this project, we used Arduino IDE to write a sketch for our controller unit and upload that sketch to the NodeMCU board. We have selected the "NodeMCU 0.1 (ESP–12E module)" from the Arduino IDE's board manager section for our project. After ensuring the proper port for NodeMCU, we have uploaded the sketch.

Blynk: Blynk platform powers low-batch manufacturers of innovative home products, complex HVAC systems, agricultural equipment, and everyone. We have created an intelligent controlling and monitoring environment with Blynk Cloud in our project. With the Blynk web application and the mobile app, the proposed system can monitor the temperature and humidity of the room and control the actuator unit smartly.

Platform Design:

An IR sensor detects human movement at night and activates the lights according to the observed light level. An LDR sensor will be used to detect the light level. The lights will be switched off throughout the day. An

AM2301 temperature and humidity sensor will be used to measure the room temperature and humidity. The fans will turn on if the temperature rises over a particular point as well as the heater will be engaged when the temperature falls below a specified threshold when the IR sensor detects movement.

To detect fire, we employ a flame sensor. MQ-135 will be used to identify the presence of harmful gasses. The MQ-135 can detect harmful gasses such as CO_2 and ammonia (NH_3). When this gas or any other type of fire is detected, certain actuators will take appropriate action to extinguish it or sound a buzzer to inform the owner. We may also operate the fans and lights manually from a distance using a smartphone app. In the, we can also view the current humidity and temperature of the room. When there is a presence of hazardous gas or fire, the app will warn you by email or mobile alert.

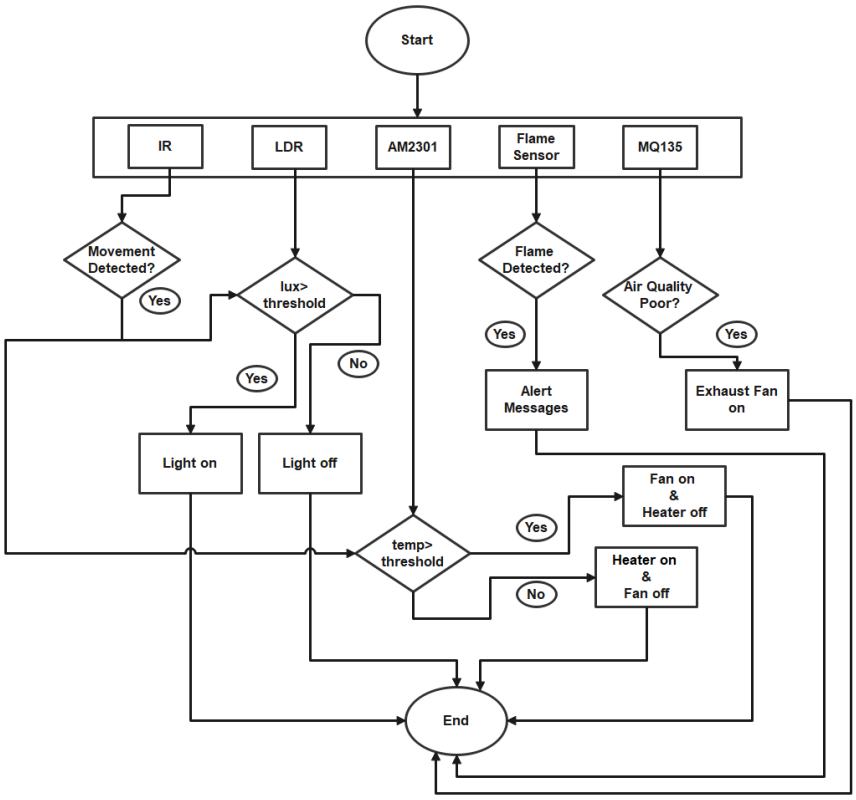


Figure 3. The proposed system's flowchart.

Experimental Result and Discussion

Here, we dealt with the results of the experiment. We described how the experiment worked before putting the IR sensor to detect human movement and the LDR sensor to turn on the inefficient light route to the test. We also used AM2301 to detect temperature and humidity, MQ135 to monitor air quality in the room, a flame sensor to detect fire, and a mobile application to receive system alert signals.

Experimental Method

We have selected the ESP8266 board (NodeMCU) for this experiment as our project's foundation. We mounted a variety of sensors and actuators to this board for testing. Finally, we create a program written in the c programming language to control all the sensors and actuators, then upload it to the NodeMCU to test the device after attaching all necessary components.

Result Analysis

The proposed system is very helpful in monitoring and controlling the smart home environment. By using this system, air quality can be continuously monitored in-home, and alerts can be sent to the user about health risks if any. The proposed system also improves security. We have shown the performance of our system in respect of switching light depending on body movements and LDR under this section. We also tested the fire detection accuracy and analyzed the air quality. We also looked at the potential to manage fans and heaters using temperature and humidity data.

Detecting Movements and Controlling Light: An infrared sensor was used to detect movement, and an LDR was used to monitor light intensity. The LDR monitors the light intensity after recognizing the presence of humans. If the intensity level falls below the threshold, the light will come on, as illustrated in Figure 4.

Detecting Temperature and Humidity: The temperature and humidity were measured with the AM2301. We can adjust the fans and heating components in our home using this. Temperature and humidity readings are continually saved on the Blynk server, which may be viewed remotely through the Blynk online dashboard and the Blynk smartphone app. Figures 5(a) and 5(b) show how to obtain data from a web dashboard. Figure 5(c) depicts the mobile control and monitoring dashboard.

Air Quality Monitoring: An MQ135 is employed in this system for monitoring the experimental environment. It can detect Ammonia, Benzene, Carbon-di-oxide, and other hazardous gases. We tested it and gathered the data from the Blynk cloud. Our method can identify the real-time air quality that is illustrated in Figure 6.

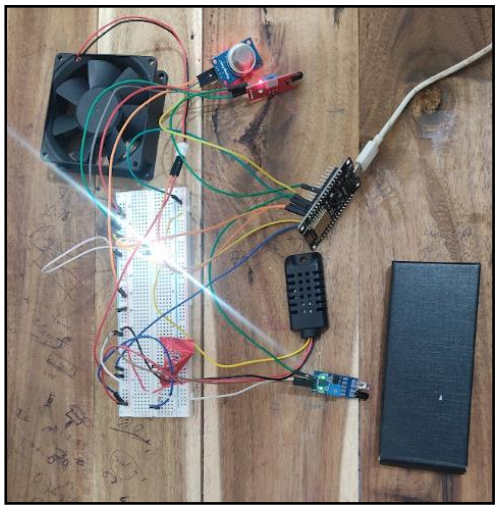


Figure 4. Detecting Movements and controlling light based on light level.

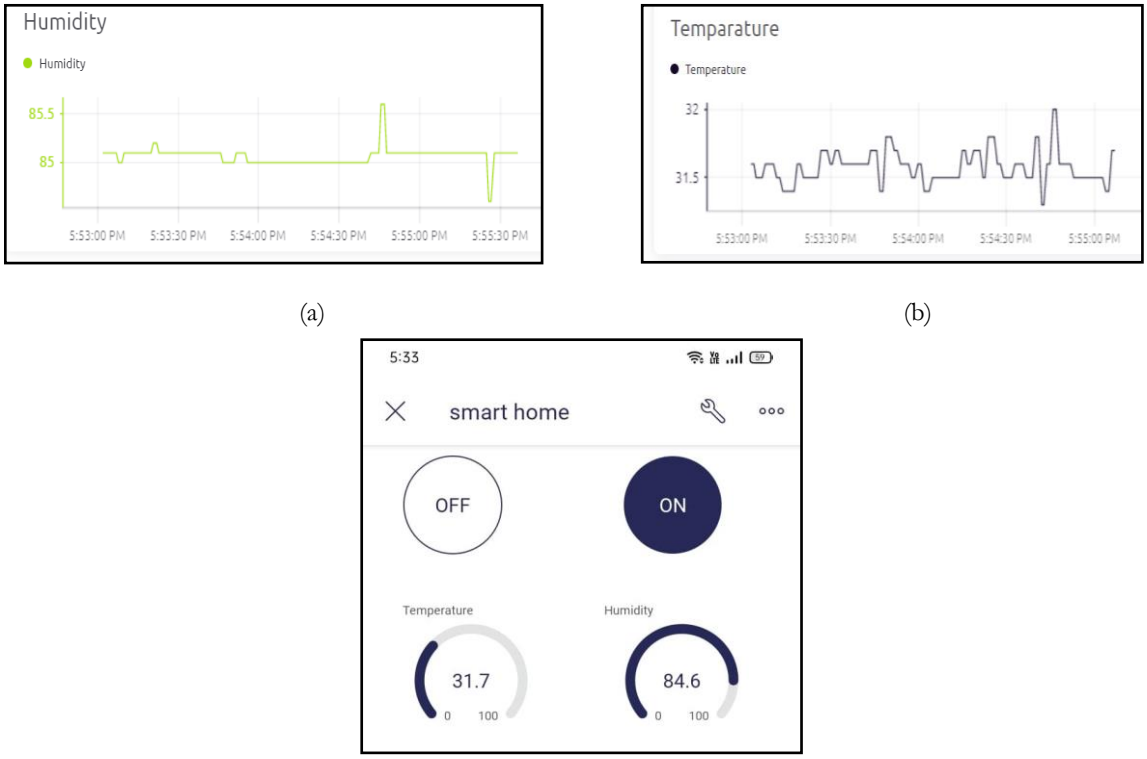


Figure 5. Monitoring real-time humidity and temperature.

Fire detection: To detect fires, we used a flame sensor in our system. Its principal function is to ensure that the flame detection system is working. If the system senses a fire or a flame, a warning message may be shown. Figure 7 displays the detection of a fire or flame within the room in real-time.

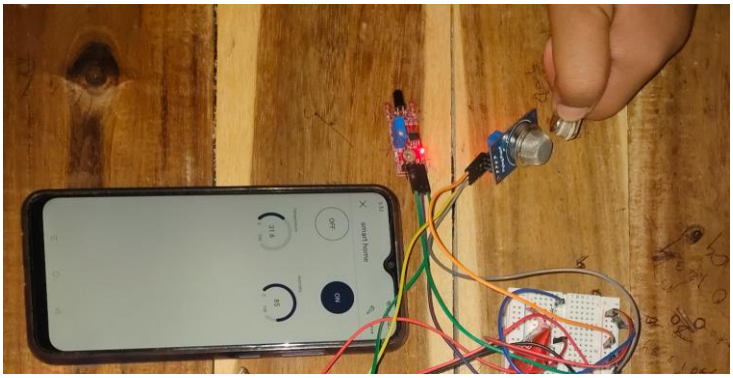


Figure 6. Monitoring air quality in real-time.

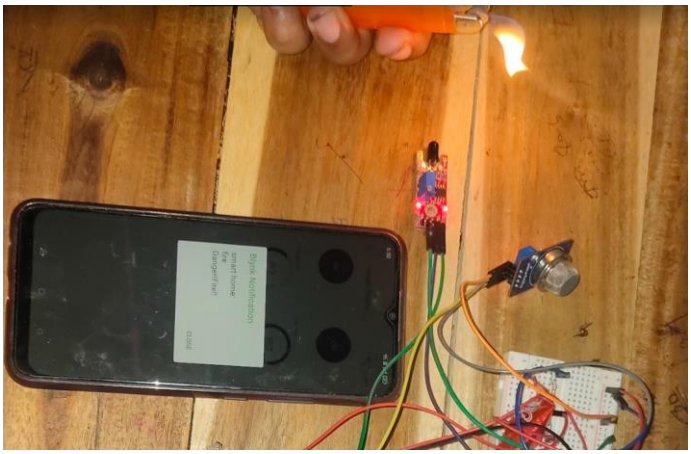
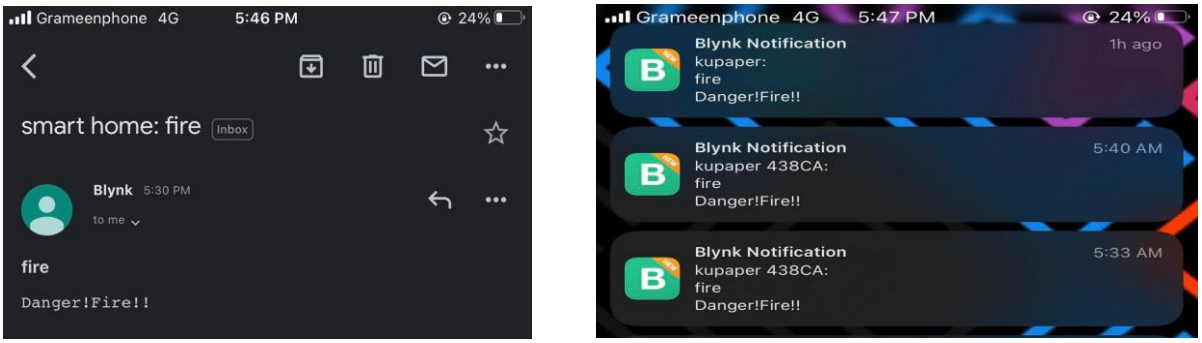


Figure 7. Real-time fire detection.

Sending Alert Message: The system uses the Blynk app to deliver alert messages to the user. When a flame sensor senses a flame, it will immediately transmit a message that works well with our system. In Figure 8(a) we can see that our system can send alerts via email. Also, the system may deliver alert messages as a mobile notification which is displayed at the Figure 8(b).



(a) (b)

Figure 8. Sending alert messages in case of fire via (a) Email and (b) mobile notification.

Comparative analysis: Table 1 below clarifies the comparison of the key features of the proposed system with numerous existing systems.The proposed approach includes the previously listed functionalities with automatic light and temperature control feature.

Table 1. Comparative Analysis with other existing works

Sl No.	Authors	Bad Gas Detection	Fire Detection	Control home appliances using 'Blynk' app	Temperature and humidity monitoring	Automatic light and temperature control
1	Patru et al., 2016	No	No	Yes	Yes	Yes
2	Sivaraman et al., 2015	No	No	Yes	No	No
3	AlHammadi et al., 2019	Yes	No	Yes	Yes	Yes
4	Khan et al., 2018	No	No	Yes	Yes	No
5	Singh et al., 2019	No	Yes	Yes	Yes	No
6	Proposed system	Yes	Yes	Yes	Yes	Yes

Conclusion

The proposed paper consists of a smart solution to automating the home, which can create a smart environment and can be performed automated. The system has an AM2301 sensor, an LDR sensor, and an MQ135 sensor to measure the environmental quality. We use an IR sensor to detect humans' presence in surroundings in this system. Here also use the flame sensor to detect any types of flame and fire. Different types of actuators control the level of light, air quality, temperature, and humidity. In the case of detecting smoke, fire, or any gas leakage, the system will notify the householder. Without automation, the safety of a house cannot be ensured. The proposed system will provide a safe environment, and it can be performed as a complete system to monitor different criteria of a house with total satisfaction. The suggested approach is inexpensive, can respond fast, notify in real-time, and be easy to maintain. The system provides a smart solution and is helpful to human beings by offering the least effort and can create a hygienic environment.

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