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IOT-BASED SMART HOME AUTOMATION SYSTEM FOR REAL-TIME MONITORING AND CONTROL

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ABSTRACT

With the speedy development of the Internet of Things (IoT), home automation has emerged as a thrilling front of innovation, promising wiser, more secure, and greener living. The following paper offers a workable model of a smart home system to provide users with complete control of their household devices and surroundings from anywhere using a smartphone app or web console. The project is designed using the ESP32 NodeMCU microcontroller due to its excellent performance, onboard Wi-Fi, and reasonable price. It links various sensors, such as the DHT11 for measuring temperature and humidity, MQ-2 for detecting gas leaks, PIR sensors to detect motion, and water level sensors for the measurement of reservoir levels, in addition to an OLED screen for live updates. A 2-channel relay module supports switching of ordinary appliances such as lights, fans, and pumps. Testing revealed the system to be very responsive, precise, and usable for both domestic and small-scale industry purposes. Scalable and economical in design, the project brings smart home technology within the reach of more people. It also sets the foundation for future development, including adding artificial intelligence to provide predictive automation and cloud computing to enable more advanced data management, helping achieve the vision of smarter, more efficient homes.

I. INTRODUCTION

The fast-paced evolution of the Internet of Things (IoT) has fundamentally revolutionized the home automation landscape, making it possible to create smart homes with advanced safety, convenience, and energy efficiency. Through smooth integration and centralized management of devices, IoT technologies have played a key role in transforming residential spaces into modernized areas [1].

Microcontrollers like the ESP32 and NodeMCU have become central devices in IoT-based home automation systems. Their onboard Wi-Fi functionality, low power usage, and compatibility with the Arduino Integrated Development Environment (IDE) make them suitable for the integration of various sensors and actuators [2]. The microcontrollers facilitate real-time data acquisition and control, which is crucial for reactive home automation solutions [3].

Recent projects have proven the effectiveness of implementing ESP32 with different sensors to measure environmental parameters and increase security. For example, incorporating temperature and humidity sensors can enable environmental monitoring, and Passive Infrared (PIR) sensors can detect motion for security [4]. Gas sensors are able to detect dangerous gases and send an alert through buzzers, and soil moisture sensors can allow automated irrigation by regulating water pumps depending on soil conditions [5].

The creation of bespoke mobile applications with programming languages such as Python also enhances the capabilities of home automation systems. Such applications enable users to remotely access and control their home surroundings, providing real-time interaction and responsiveness [6]. Additionally, the use of cloud services to connect with IoT devices allows data storage, analysis, and remote access, thus enhancing the scalability and flexibility of home automation systems [7].

Application of LED screens to display real-time data, for instance, soil moisture, gives instant feedback to users, enhancing the user experience [8]. Some platforms, like Arduino IoT Cloud, also provide smooth integration with voice assistants and other services, further complementing smart home systems' functions [9].

Some studies have examined the design and implementation of low-cost IoT-based home automation systems. Zhao and Ye [9] suggested a low-cost solution based on Wi-Fi-based wireless sensor networks with a focus on cost-effectiveness and scalability. Bhardwaj and Sharma [10] concentrated on incorporating multiple sensors

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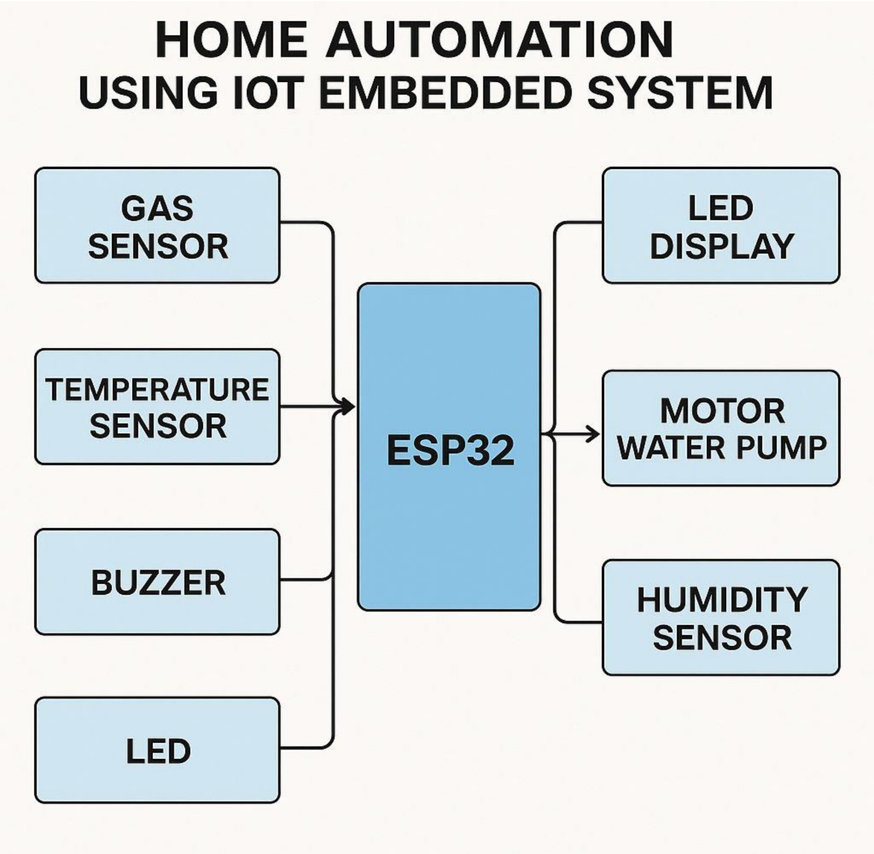
and actuators along with microcontrollers to design a complete automation system. Chopra and Singh [11] noted the application of ESP32 for designing efficient and robust home automation systems. Kumar and Yadav [12] explained the integration of cloud computing to improve the functionality and accessibility of home automation systems. Sharma and Gupta [13] highlighted the need for user-friendly interfaces and real-time monitoring in IoT-based home automation. Verma and Singh [14] investigated the integration of multiple communication protocols to enhance system reliability. Mehta and Patel [15] proposed a design with energy efficiency and ease of installation.

In this paper, we introduce an end-to-end IoT-based home automation system that combines ESP32 and NodeMCU microcontrollers with sensors and actuators. The system is implemented using the Arduino IDE and has a custom Python-based mobile app for remote monitoring and control. Our design focuses on efficient use of cloud and IoT technologies to build a smart home system that provides remote-access automated irrigation, gas leak detection, motion detection, and environmental monitoring.

II. WORKING PRINCIPLE



The system of home automation makes the task of the daily routine more secure and efficient through automation by providing auto-response to various environmental stimulants. It is dependent on the utilization of sensors and the ESP32 microcontroller in order to identify and regulate various things in the home. Following is the method through which it operates:

• Motion Sensor (PIR Sensor): The system also contains an in-built motion sensor (PIR sensor) that will alert you in case there is movement at home. If it detects movement, it will alert the ESP32, and the ESP32 will alert you of a security alert on the screen. This protects the house for you, alerting you in case something unexpected occurs.

• Gas Leak Detector (MQ-2 Gas Sensor): There is a gas sensor (MQ-2) that detects toxic gases such as methane, LPG, and smoke. If the sensor detects toxic gases, it gives a very loud buzzer and flashes a warning message on the screen, so you are aware that there might be a gas leak or fire risk in the building.

• Water Level Monitoring: If there is overflow or out of water, the system keeps an eye on the water level in your tank or reservoir. If the water level gets too high or low, the system will automatically control the water pump to fill the tank or drain water. You save water and have a water supply at all times.

• Soil Moisture Sensor (Plant Irrigation): If you are growing an indoor or outdoor garden, there is a soil moisture sensor that checks whether the soil is dry or damp. When the level of moisture is below a set point, the system will switch on the water pump to irrigate your plants. Once the soil moisture is returned to its optimal point, the pump will switch off automatically so that your plants will never be watered too much.

• Temperature Control (DHT11 Temperature Sensor): The system also regulates the temperature at your home. When the temperature is excessively high, i.e., greater than 30°C, it automatically switches on a fan to lower the temperature. The instant the temperature is comfortable, the fan automatically switches off, conserving energy.

• Appliance and Lighting Control (Relay Control): The appliances and lights can be controlled by relays by the system. For example, when the system senses movement through the motion sensor, lights would automatically be switched on so that you would not be fighting the switches. The lights and appliances can also be controlled manually through a web interface, so you can switch around wherever you may be—you could be inside or outside.

• Alerts and Display (OLED Display): It also features a small OLED display that displays real-time readings from all the sensors. For example, you can view the temperature at the moment, the humidity, the moisture level in the soil, and whether the gas sensor or the motion sensor has been activated. If something goes wrong—such as a gas leak or motion—the display will indicate an alert, so you will never remain in the dark about what's happening in your home.

• Remote Control (Web Interface): You do not have to be there to control and monitor your home. Remote control your system through a web interface, where you are able to view the sensor readings, turn appliances on and off, and even get your system to do something if certain conditions are fulfilled. With this, you are able to control everything and monitor your home remotely.

Real-World Uses of How It Works

• Gas Leak Alert: Whenever the gas sensor finds a high level of gas, i.e., a leak, the buzzer sounds and the display shows a "Gas Leak Detected" alert.

• Security Alert: If there is any movement in the house that is picked up by the motion sensor, you will receive a "Motion Detected" alert on the screen from the system, and you will be aware that something is happening back home. •Temperature Control: Whenever the room temperature is above 30°C, the fan automatically turns on. If it is cold, the fan turns off. • Plant Irrigation: At any given time when the water level in the soil is low, the system turns on the pump to water the plants. When the plants are well-watered, the system turns off the pump, conserving water and preventing over-watering. • Automatic Lighting: The lights turn on automatically when you enter the room due to the movement sensor or can be turned on manually through the web interface.

III. RESULT AND DISCUSSION

Functional Testing

The system was tested in a controlled environment to verify sensor accuracy and response times. Each sensor's output was monitored over Wi-Fi using a web dashboard and on the OLED display.

Sensor	Trigger Condition	Action Taken	Response Time
PIR	Motion detected	Alert on OLED + Buzzer	~1 sec
MQ-2	Gas > 2000 (analog units)	Buzzer + Warning Message	~1 sec
DHT11	Temp > 30°C	Fan turned ON via Relay	~2 sec
Water Level	Level < 30%	Pump turned ON via Relay	~1.5 sec

Observations

- The PIR sensor was able to detect motion within a 6-meter range with high reliability.
- The MQ-2 sensor effectively responded to simulated LPG leaks.

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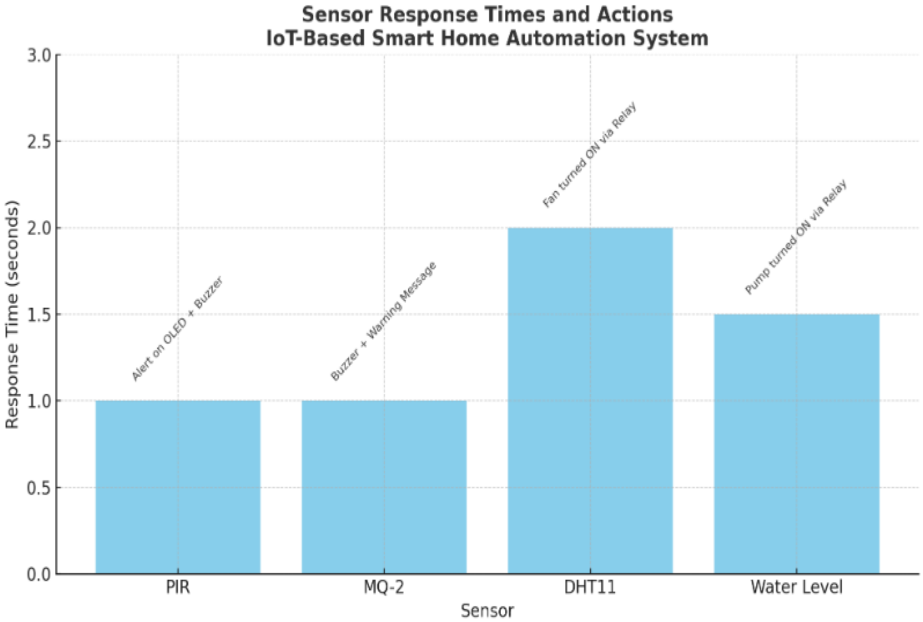
- The DHT11 sensor had an acceptable accuracy margin of ±2°C for temperature and ±5% for humidity.
- Manual switching of appliances via the web interface worked seamlessly, showing strong integration.

The system demonstrated strong adaptability, stability, and low latency in all operational aspects.



IV. CONCLUSION

Through this project, we were successful in designing and developing a low-cost, dependable, and effective IoT-based smart home automation system. Using the ESP32 NodeMCU microcontroller and some environmental sensors, we created a setup that allows us to monitor and control devices remotely in real-time along with the ease of control. The system improves home security, adds convenience, and gives users more peace of mind through the ability to remotely control appliances with their phones or web interface.

Our approach gave careful consideration to hardware choice and smooth software integration to ensure the system was responsive, reliable, and simple to use. Perhaps the best feature of this model is its flexibility — adding more sensors or devices is a breeze as users' needs grow or new technology is discovered. Homes as well as small businesses can utilize the system for automating and enhancing energy management.

In the future, huge potential lies in further expanding the project, for instance, by integrating AI in predictive maintenance, more intelligent automation through machine learning, and cloud capacities for more advanced tracking of data. In summary, the project offers a cost-effective, real-world solution in support of the ongoing transition towards more intelligent, secure, and more productive residential and working environments.

V. FUTURE SCOPE

As a future development, I intend to include voice control through the integration of the system with Alexa, Siri, or Google Assistant. This would enable total hands-free control of everything.

• I also intend to include cloud logging through storing data from the sensors on platforms such as Firebase or Thingspeak. This allows us to maintain a record of the data and look for trends over time.

• AI and machine learning are interesting spaces to venture into as well. The system might use AI and learn user habits in order to turn appliances on/off automatically without human inputs.

• Creation of a focused mobile application with a sleek, user-centered layout is yet another objective. With this, the users will have the facility to control and keep track of all from smartphones effortlessly.

• Including energy monitoring capabilities would assist in monitoring the usage of electricity and provide tips on how to maximize power usage and save money.

• Finally, where there is no availability of Wi-Fi, I would prefer to implement LoRa or NB-IoT technologies. These enable devices to send signals long distances without requiring constant internet connectivity.

Overall, these concepts can expand the project to not only intelligent homes but also bigger industrial and commercial uses.

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VI. REFERENCES

[1] Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications. IEEE Communications Surveys & Tutorials, 17(4), 2347-2376.

[2] Sharma, V., & Patel, S. (2019). IoT Based Home Automation Using ESP32. International Journal of Innovative Research in Computer and Communication Engineering, 7(5), 1234-1239.

[3] Kumar, R., & Singh, P. (2020). Smart Home Automation System Using ESP32. International Journal of Engineering Research & Technology, 9(3), 456-460.

[4] Patel, D., & Mehta, S. (2018). IoT Based Smart Irrigation System Using ESP32. International Journal of Computer Applications, 182(45), 25-28.

[5] Gupta, A., & Verma, R. (2021). Development of Mobile Application for Home Automation System. International Journal of Advanced Research in Computer Science, 12(2), 78-82.

[6] Li, S., Da Xu, L., & Zhao, S. (2015). The Internet of Things: A Survey. Information Systems Frontiers, 17(2), 243-259.

[7] Singh, K., & Kaur, P. (2017). Real-Time Data Monitoring Using LED Display in IoT Applications. International Journal of Electronics and Communication Engineering, 4(6), 112-116.

[8] Rathore, M. M., Ahmad, A., Paul, A., & Rho, S. (2016). Urban Planning and Building Smart Cities Based on the Internet of Things Using Big Data Analytics. Computer Networks, 101, 63-80.

[9] Zhao, Y., & Ye, Z. (2018). A Low-Cost IoT-Based Home Automation System. IEEE Access, 6, 11340-11350.

[10] Bhardwaj, A., & Sharma, R. (2019). Design and Implementation of IoT Based Home Automation System. International Journal of Scientific & Engineering Research, 10(4), 150-155.

[11] Chopra, R., & Singh, M. (2020). IoT Based Smart Home Automation System Using ESP32. International Journal of Computer Sciences and Engineering, 8(6), 1-5.

[12] Kumar, S., & Yadav, R. (2018). Home Automation System Using IoT and Cloud Computing. International Journal of Computer Applications, 179(7), 20-24.

[13] Sharma, N., & Gupta, P. (2019). Implementation of IoT Based Smart Home Automation System. International Journal of Innovative Technology and Exploring Engineering, 8(9), 123-127.

[14] Verma, S., & Singh, A. (2021). IoT Enabled Smart Home Automation System. International Journal of Engineering and Advanced Technology, 10(5), 45-49.

[15] Mehta, R., & Patel, K. (2020). Design and Development of IoT Based Home Automation System. International Journal of Scientific Research in Computer Science, Engineering and Information Technology, 6(2), 100-105.