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Design and Implementation of an IoT-Based Smart Home Automation System Using ESP32

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ABSTRACT

This research presents ESP32-based IoT-based smart home automation system design and execution. This system uses the powerful ESP32 microcontroller with Wi-Fi and Bluetooth to remotely control and monitor household appliances and sensors. The system's main components include an IR sensor, gas sensor, temperature sensor, DHT11 sensor, moisture sensor, 16x2 LCD display, four relays, four loads, DC motor, water motor, and buzzer. IR motion detection detects unauthorised entrance, improving security. To ensure safety, the gas sensor detects dangerous gases including LPG, smoke, and methane in indoor air. The temperature sensor and DHT11 sensor measure ambient temperature and humidity, essential for a pleasant and healthy home. Automated irrigation systems benefit from soil moisture sensors. The system's 16x2 LCD display shows sensor and device status in real time. Four relays control lights, fans, and other home appliances for automatic or manual switching. The device also has a DC motor and water motor for automating window blinds and irrigation pumps. Users are alerted by a buzzer for gas leakage or unauthorised entry. This user-friendly smart home automation system allows remote control by smartphone or web interface. Integration of sensors and actuators makes the system a complete contemporary home automation solution. This system shows how IoT may improve domestic efficiency, safety, and convenience.

Keywords— ESP32; Smart Home Automation, IoT, Home Security, Home Appliances.

1. INTRODUCTION

The advent of Internet of Things (IoT) technology has significantly transformed various industries, particularly home automation. IoT-based systems enable seamless integration of everyday devices with the internet, allowing users to monitor and control their home environment remotely. This technological evolution has led to the development of smart homes, where automation not only enhances convenience but also improves safety, efficiency, and energy management.

This project focuses on the design and implementation of a comprehensive IoT-based smart home automation system using the ESP32 microcontroller. The ESP32 is chosen for its robust features, including integrated Wi-Fi and Bluetooth capabilities, low power consumption, and extensive GPIO options, making it ideal for IoT applications. The system integrates a variety of sensors and actuators to automate and manage different aspects of the home environment [1]. To enhance home security, the system incorporates an infrared (IR) sensor that detects motion, thereby identifying potential unauthorized entries. Additionally, a gas sensor is used to monitor indoor air quality by detecting the presence of hazardous gases such as LPG, smoke, and methane. This functionality is crucial for preventing gas leaks and ensuring the safety of the inhabitants. A buzzer is included to provide audible alerts in case of security breaches or dangerous gas levels, prompting immediate action. The system employs a temperature sensor and a DHT11 sensor to measure ambient temperature and humidity, respectively. These sensors provide crucial data for maintaining a comfortable and healthy living environment. Furthermore, a moisture sensor is integrated to monitor soil moisture levels, facilitating automated irrigation systems that ensure optimal water usage [2]. A 16x2 LCD display is included to provide real-time data and status updates from the various sensors, enhancing user interaction and awareness. The system features four relays to control different electrical loads such as lights, fans, and other household appliances, offering both automated and manual control options. Additionally, it incorporates a DC motor and a water motor for specific automation tasks, such as adjusting window blinds and operating water pumps for irrigation. Designed to be user-friendly, the smart home automation system allows remote control and monitoring through a smartphone application or web interface. This enables users to manage their home environment efficiently from anywhere, at any time. The integration of multiple sensors and actuators into a single cohesive system demonstrates the potential of IoT technology to enhance the quality of life by making homes smarter, safer, and more efficient [4]. This project underscores the transformative impact of IoT in everyday living spaces, illustrating how technology can be harnessed to create more responsive, intelligent, and adaptive home environments. By leveraging the capabilities of the ESP32 microcontroller and the suite of sensors and actuators, this smart home system exemplifies the convergence of convenience, security, and sustainability in modern living [5]. There are several ways to describe a smart house. The term "smart home" may refer to a variety of different things, but one common meaning is a house equipped with sensors and device controllers that work together to provide a safe, intelligent, and pleasant environment for all residents, especially those with mobility issues or other impairments. Using a wireless communication interface like Bluetooth or Wi-Fi, the SH automation system (illustrated in Fig. 1) may connect household appliances to a smartphone or personal computer.

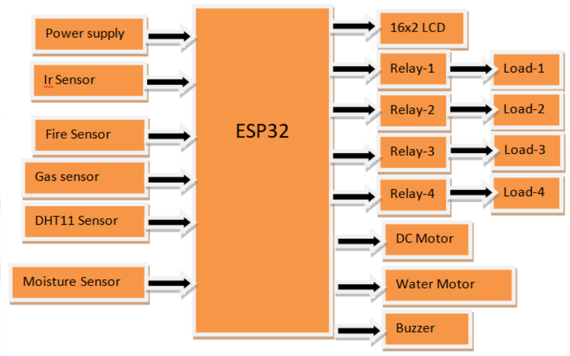

Figure.1 Proposed schematic block diagram

Home automation systems (HAS) abound on the market, and the vast majority of them fall into one of two broad types: those that can be operated locally and those that can be operated remotely. First, there's home automation using in-home controllers that employ either fixed or wireless communication technologies (such as Bluetooth, Zigbee, and GSM) to operate appliances [6]. The second kind allows consumers to manage their houses from anywhere with an Internet connection, whether it's on a personal computer, a mobile device, or both. On the other hand, it's important to think about the many challenges that come with building this kind of automated system. An intuitive interface is essential for home automation systems so that users can quickly and simply set up, monitor, and operate their various appliances.

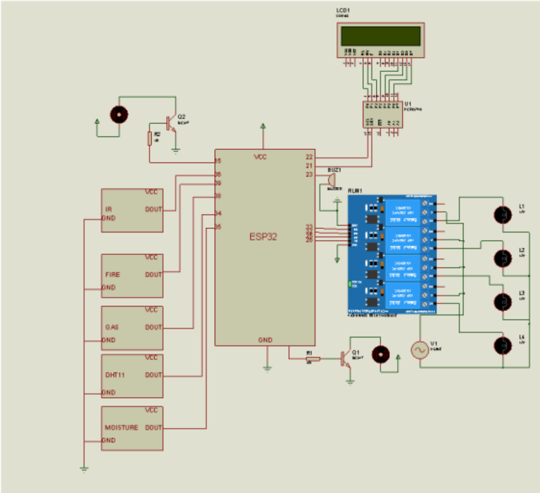

Figure. 2 Proposed schematic circuit diagram

To get the most out of wireless technology, the automation system also needs a fast enough connection, a dependable data rate, and a good enough communication range. At last, the system has the necessary components for home automation and can defend its use [7]. This article suggests integrating home automation technologies that can be operated locally and remotely in order to circumvent these design challenges and reduce the system's weaknesses. In addition to remotely controlling the system via the Internet of Things (IoT), the proposed system will also provide a locally controlled system for home automation using a Wi-Fi interface and the inexpensive Arduino microcontroller [8]. The system can function regardless of the user's location or cell carrier because of this. Individuals may manage, monitor, and control their appliances and gadgets over the Internet, and the built automation system can be accessed locally with a variety of Android-based smartphones via Wi-Fi.

2. Home Security System

A. Home Automation Systems

The "Internet of Things," which includes home automation systems like Smart Homes, allows for the remote monitoring and control of any device, anywhere in the world thanks to its unique Internet Protocol (IP) address. It is the method by which a smart home's many appliances and gadgets are linked together to provide complete command and management. Home automation systems have been focused on controlling lights and basic appliances for quite a while. In recent times, technological advancements have made it possible to operate our smart home devices remotely, making the concept of a linked world a reality [9]. With home automation, you can tell a gadget when, why, and how to respond. With it, you have complete command, ease of use, and cost savings. In addition, the user may get notifications when certain events happen in their house, such as gas leaks, water leaks, fires, or unauthorised entry, even while they are not there. The user may adjust the automation system's settings whenever he wants using an Android app or other control device, according to his needs and preferences.

B. Why Smart Home?

The sophisticated lighting management system is one advantage of SH. Electric appliances no longer need the user to physically turn them on or off. As an example, when the user walks into the bedroom, they have two options: either the light will turn on and off automatically when they leave the room, or they may use their smartphone app to manage the switching. You may also adjust the light's brightness to lower the power consumption. Additionally, the user may customise the room's environment by responding to sensor data (such as temperature and humidity) in a variety of ways, such as by controlling the fan speed using the mobile app or having it modified automatically depending on the room temperature. Electrical appliances may be set to switch off automatically or with a simple push of a button when they are not in use, greatly improving energy efficiency and reducing the cost of monthly electricity bills. Moreover, the user may manage the home's electrical equipment and keep tabs on its status from any location using a laptop, smartphone, or tablet. Forgetting to turn off the fan before getting to work? No problem! Just pull up the appropriate app on your smart device and flip the switch. Users may also add smoke, carbon monoxide, and flood sensors. This way, if their house is in danger from flooding or harmful air, they can remain inside. If something goes wrong with the security system, the user will get a notification on their phone. They can rest easy knowing that their home is protected from any potential intruders; all they need is a motion detector, which they can install on their phone. The alarm will go off the moment it detects motion. To prevent unwanted visitors or criminals from entering our home, the security system is crucial. We may install wired surveillance cameras as part of a home security system to deter would-be intruders. Every part of a smart home, including HVAC, lighting, ventilation, heating, and air conditioning, automated appliances, and security systems, may make life easier and safer.

C. Limitations of the Existing HAS

Previous studies have shown that the high expense of implementing and maintaining most current HAS is a major drawback that prevents them from being accessible to the majority of users. On top of that, consumers have to go online every time they want to check on their homes or make changes to them since some existing systems only let them do so via a web app [10]. There are also certain HAS that don't have good interfaces for controlling and monitoring appliances. Furthermore, the current automation systems have some restrictions due to the communication technologies that have been used. Take Bluetooth as an example; its maximum communication range is 10 metres. The user will lose control of their home appliances if the distance is more than 10 metres. Additionally, ZigBee's 250 kbps data rate is inadequate for low-rate wireless personal area networks. While GSM is another global communication option, it comes at a high price, transmits data at a slow pace, and has poor coverage in rural regions [11]. As a result, we provide a novel approach in this study to address the shortcomings of current home automation solutions. One way to do this is by creating a prototype of a smart home automation system that uses an Arduino microcontroller and an Android-based smartphone. It will be inexpensive and easy to implement. With the help of the Internet of Things (IoT), the system is designed to make it easy and efficient to handle all of the electrical appliances in one's house. It also enables remote control.

3. METHODOLOGY AND MATERIALS

A. Conceptual Framework

The flowchart begins with the initiation of the process, symbolized by "Start". As the user interacts with the smart home system through devices like smart phones or tablets, their commands and requests are received by the system. These inputs could involve controlling lights, appliances, or monitoring aspects like temperature, motion, or security status. Upon receiving user inputs, the system checks their nature. It distinguishes between commands for device control and requests for monitoring or security checks. If the input involves controlling lights or appliances, the system executes corresponding commands as shown in figure.3.

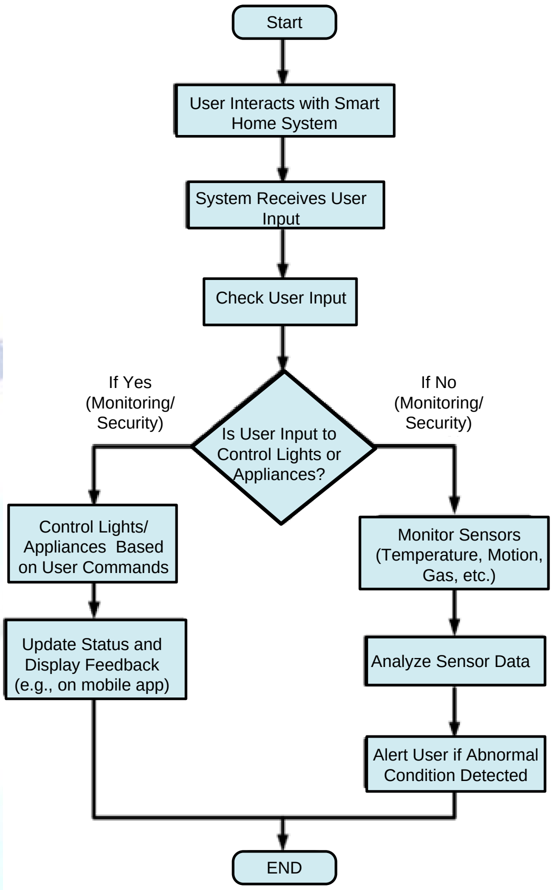

Figure.3 Flowchart of system working activities

This could include turning devices on/off, adjusting settings, and providing feedback on actions taken. Alternatively, if the input is for monitoring or security purposes, the system initiates sensor monitoring throughout the home. Sensors such as temperature sensors, motion detectors, and gas sensors continuously gather data on environmental conditions and security status. The collected sensor data is then analyzed to detect anomalies or risks, such as unusual temperature changes or unauthorized movements. Based on this analysis, the system triggers alerts or notifications to inform the user of detected events, such as water leaks, gas leaks, or security breaches. Throughout the process, the system updates the status of controlled devices, provides feedback to the user via interfaces like mobile apps, and ensures timely responses to maintain home security and efficiency. The flowchart concludes with an "End" symbol, marking the completion of the process flow for device control, monitoring, and security management in the smart home environment. The flowchart visually outlines how a home automation system processes user inputs, manages device control, monitors environmental parameters, and ensures security through continuous data analysis and alert mechanisms.

B. Main Components of Home Automation System

ESP32:

In the context of smart home automation, the ESP32 microcontroller operates as the central processing unit that facilitates the integration and control of various IoT devices and sensors. Equipped with dual-core processors running at up to 240 MHz, the ESP32 efficiently manages tasks such as data acquisition from sensors and communication with other devices as shown in figure.4. Sensors like temperature, humidity, motion detectors, and gas sensors are connected to the ESP32 through GPIO pins using protocols like I2C or SPI. These sensors continuously gather environmental data, which is then processed by the ESP32 to make decisions based on predefined logic or algorithms. For instance, based on temperature readings, the ESP32 can activate or deactivate heating or cooling systems. It can also monitor motion sensors to detect movement and trigger security alerts or adjust lighting based on occupancy. With built-in Wi-Fi and Bluetooth connectivity, the ESP32 enables seamless communication with smartphones, tablets, or other IoT devices, allowing users to remotely monitor and control their home environment. This capability makes the ESP32 a versatile and essential component in creating smart homes that offer convenience, energy efficiency, and enhanced security.

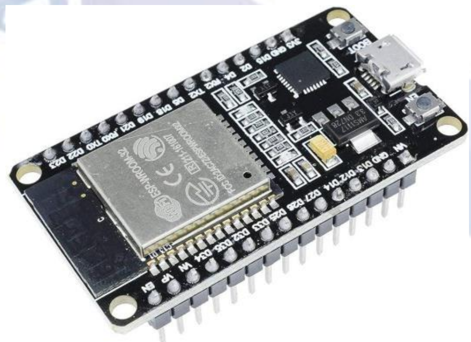

Figure.4 ESP-32 WiFi , Bluetooth, Dual Core Chip

DHT11 Sensor:

In the realm of smart home automation, the DHT11 sensor operates as a fundamental component for monitoring temperature and humidity levels within the household environment. Connected to microcontrollers such as Arduino or ESP32, the DHT11 sensor utilizes a digital communication protocol to relay data in the form of digital signals as shown in figure.5. This sensor continuously measures ambient temperature and humidity, converting these analog measurements into digital outputs that are then processed by the microcontroller. Through data processing, which includes interpreting these signals into readable temperature values (in Celsius or Fahrenheit) and relative humidity percentages, the microcontroller can make informed decisions. For instance, based on predefined thresholds, it can initiate actions like activating heating or cooling systems to maintain comfortable indoor temperatures. Similarly, if humidity levels exceed desired parameters, the microcontroller may trigger ventilation systems or dehumidifiers. Moreover, in the context of a smart home setup, this data can be integrated into broader automation systems, enabling users to remotely monitor and control environmental conditions via mobile apps or web interfaces. This capability not only enhances convenience but also supports energy efficiency and proactive management of indoor comfort levels.

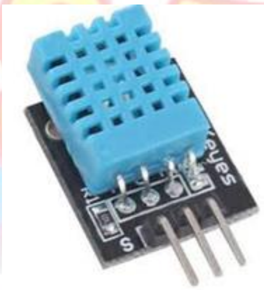

Figure5 DHT11 sensor pinout

Gas Sensor:

The MQ-137 NH3 gas sensor is a crucial component in smart home automation systems, detecting and monitoring air quality. It uses a tin dioxide (SnO2) semiconductor sensing element to change its conductivity in the presence of ammonia gas, converting the analog signal into a measurable output as shown in figure.6. The sensor is connected to a microcontroller like Arduino or ESP32, which requires a heater element to operate. The microcontroller reads the analog signal and processes it to determine the concentration of ammonia gas present. This data processing may involve calibration and conversion algorithms to accurately measure and interpret the gas concentration levels. Based on the measured ammonia levels, the microcontroller can execute predefined actions, such as triggering alerts or notifications if the concentration exceeds safe thresholds or activating ventilation systems or air purifiers to mitigate ammonia presence and improve indoor air quality. Integration into the smart home system allows users to monitor ammonia levels remotely via smartphone apps or web interfaces, providing homeowners with valuable insights into indoor air quality and enabling proactive measures to maintain a healthier living environment.

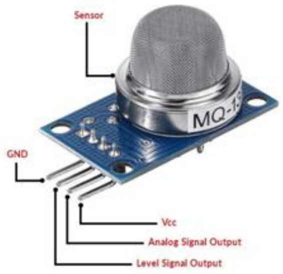

Figure.6 MQ-137 NH3 Gas Sensor

Soil Moisture Meter Soil Humidity Sensor Water Sensor

The Soil Moisture Meter or Soil Humidity Sensor is a crucial component in smart agriculture and automated gardening systems within smart homes. These sensors measure the volumetric water content in the soil, indicating the level of moisture available to plants. The sensor consists of two probes that measure the conductivity between them, which varies with the amount of water present in the soil as shown in figure.7. When soil moisture is high, water serves as a conductor, allowing for stronger current flow between the probes. In operation, the soil moisture meter or sensor is connected to a microcontroller such as Arduino or ESP32, which monitors the resistance or conductivity readings from the sensor probes. This data processing often involves calibration to account for soil types and environmental conditions, ensuring accurate measurements. Based on the moisture level readings, the microcontroller can initiate automated actions to manage irrigation or watering systems efficiently. Integration into the smart home system allows users to monitor soil moisture levels remotely via smartphone apps or web interfaces. This real-time monitoring capability provides gardeners and farmers with valuable insights into the soil conditions, enabling them to adjust watering schedules, optimize plant growth, and conserve resources effectively. In summary, the soil moisture meter or soil humidity sensor plays a crucial role in smart home automation by enabling automated and efficient management of watering systems based on real-time soil moisture data.

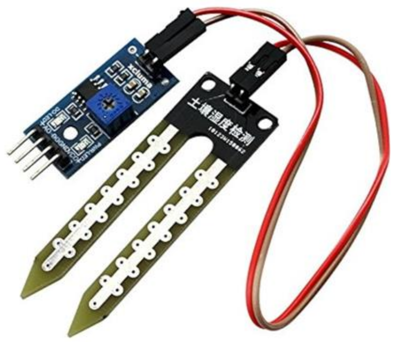

Figure.7 Soil Moisture Sensor

Relay board

A relay board is a crucial component in smart home automation systems, serving as a switch mechanism to control high-power electrical devices using low-power microcontrollers or logic signals. It consists of multiple relays, each capable of independently switching electrical circuits on or off as shown in figure.8. A microcontroller, such as Arduino or ESP32, sends control signals to the relay board based on user inputs or predefined automation routines. When a microcontroller sends a signal to activate a relay, it energizes an electromagnet within the relay, causing the switch contacts to change position, either closing or opening the electrical circuit connected to the relay board. In a smart home setup, a relay board might control devices like lights, fans, heaters, or pumps. When a user triggers a command through a smartphone app or sensor, the microcontroller interprets this input and sends a corresponding signal to the relay board. The relay board's integration into the smart home system enhances convenience, energy efficiency, and safety by allowing users to manage devices remotely, schedule operations, and create sophisticated automation routines. It often includes features like isolation to protect low-voltage control circuits from high-voltage loads, ensuring reliable and safe operation within the smart home environment.

Fig. 8 Relay board

IR sensor

Infrared (IR) sensors are essential in smart home automation for enhancing convenience, security, and energy efficiency. They are able to detect infrared radiation that objects within their detection range emit or reflect, enabling motion detection systems to activate lights, sound alarms, or send notifications to homeowners as shown in figure.9. This enhances security by alerting occupants to potential intrusions and provides a layer of automation that responds to detected movement without human intervention. IR sensors also enable proximity sensing, which is used in touchless interfaces for appliances like faucets and doors. By detecting reflected infrared light, these sensors can determine when a user is nearby, triggering automated actions. Advanced IR sensors support gesture recognition technology, allowing users to control smart devices through specific hand movements. This feature is increasingly integrated into smart TVs and entertainment systems, enhancing user interaction and convenience. Overall, IR sensors play a pivotal role in smart home automation by providing reliable motion detection, proximity sensing, and gesture recognition capabilities, enhancing safety, comfort, and efficiency.

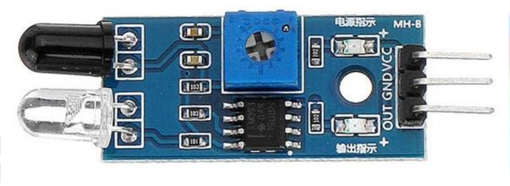

Figure.9 IR sensor

Electric DC motors

DC Motor: DC motors operate based on the principles of electromagnetism, where electrical energy is converted into mechanical rotation. In smart homes, these motors are commonly used in applications requiring precise speed control and efficient operation as shown in figure.10. They can be integrated into automated systems for tasks such as opening and closing blinds, adjusting window louvers, or controlling robotic devices like vacuum cleaners. DC motors are preferred for their compact size, high efficiency, and ability to be controlled using pulse width modulation (PWM) signals from microcontrollers like Arduino or ESP32. This enables homeowners to adjust motor speed and direction remotely via smart devices, optimizing energy usage and enhancing convenience.

Figure.10 DC motor

Water Motor: Water motors, often referred to as water pumps, are crucial for automated irrigation systems and water management within smart homes. These motors utilize electrical energy to pump water from a source to designated areas, such as gardens or lawns, based on predefined schedules or sensor inputs as shown in figure.11. They are equipped with sensors that monitor water levels or soil moisture, allowing them to activate automatically when irrigation is needed. Water motors can be controlled using microcontrollers to regulate flow rates and durations, ensuring efficient water distribution while conserving resources. Integration with smart home automation platforms enables remote monitoring and control, empowering homeowners to adjust irrigation schedules and manage water usage efficiently from anywhere via Smartphone apps or web interfaces.

Figure.11 water motor

Buzzer

In the realm of smart home automation, buzzers play a crucial role as auditory indicators. They convert electrical signals into audible sound waves through their vibrating element, often a piezoelectric component or an electromagnetic coil. These buzzers provide immediate notifications and alerts, such as indicating the activation of security systems or warning occupants of potential dangers like fire, smoke detection, or intrusions. This enhances home security by allowing for timely responses and necessary actions as shown in figure.12. Buschers also serve as feedback mechanisms in automated systems, providing audible confirmation of completed tasks or changes in operational states. They can signal successful door locking, appliance activation, or environmental settings adjustments. This feedback enhances user interaction by providing real-time auditory cues that complement visual or mobile app notifications. Buschers also act as warning signals for system malfunctions or maintenance requirements. They can alert users to low battery levels, sensor failures, or faults in automated processes, prompting homeowners to address issues promptly. In essence, buzzers' role in smart home automation extends beyond simple alerting to encompass feedback provision and system monitoring, enhancing convenience, safety, and operational efficiency within the modern home environment.

Figure.12 Buzzer

4. SYSTEM ARCHITECTURE AND IMPLEMENTATION

The system architecture revolves around the ESP32 microcontroller as the central processing unit, which facilitates wireless communication and coordination among all connected devices. Sensors are strategically deployed throughout the home environment to collect data on motion, air quality, temperature, humidity, and soil moisture. These sensors transmit data to the ESP32, which processes the information and triggers appropriate actions through connected actuators. Actuators include relays that enable the control of electrical devices like lights and appliances based on sensor inputs or user commands. A DC motor and a water motor are employed for tasks such as adjusting window blinds, managing irrigation systems, or operating mechanical fixtures, all orchestrated through the ESP32's control logic. User interaction and system feedback are facilitated by a 16x2 LCD display, providing real-time status updates and sensor readings. The system's operational intelligence is enhanced by the integration of a buzzer for audible notifications, alerting users to security breaches or system malfunctions promptly. Communication within the system is established via Wi-Fi connectivity, enabling seamless interaction with a dedicated smartphone application. This application allows homeowners to monitor and control their smart home environment remotely, adjusting settings, receiving alerts, and ensuring optimal management of energy resources and environmental conditions. This architecture and implementation outline demonstrates a robust IoT-based smart home automation system, designed to enhance living comfort, efficiency, and security through intelligent sensor integration, responsive actuation, and intuitive user interfaces.

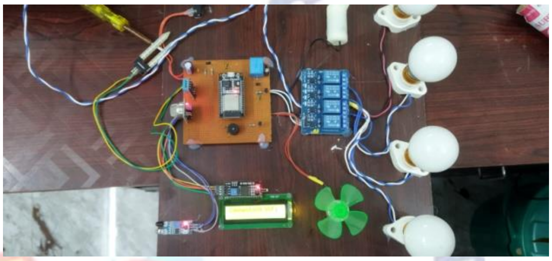

Fig. 13 The proposed system architecture

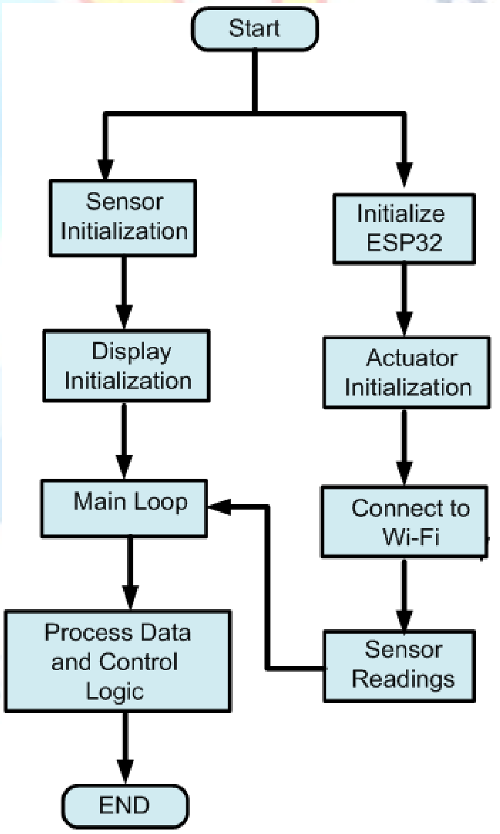

Fig. 14 Flowchart of project setup

5. RESULTS AND DISCUSSION

The IoT-based smart home automation system using ESP32 demonstrated impressive results in sensor performance, actuator responsiveness, user interface, energy efficiency, and security enhancements. The sensors included IR, gas, temperature, DHT11, and moisture sensors, which performed reliably throughout the testing phase. The IR sensor detected motion within a 10-meter range, providing security applications. The gas sensor provided accurate air quality readings, enabling prompt alerts for harmful gas presence. Temperature and humidity levels were consistently monitored, facilitating efficient climate control. The moisture sensor measured soil moisture, allowing for automated irrigation management. The actuators, such as relays, DC motor, and water motor, responded swiftly to control commands, managing electrical loads, adjusting mechanical fixtures, and managing irrigation. The 16x2 LCD display enhanced user interaction, while the smartphone application enabled remote monitoring and control. The system achieved significant savings by automating the control of lights, appliances, and HVAC systems based on real-time sensor data. This automation not only enhanced user convenience but also resulted in lower electricity bills, demonstrating the potential for cost savings in a smart home setup. Security and safety were improved through the integration of motion detection, gas sensing, and environmental monitoring capabilities. The buzzer provided audible alerts for immediate attention, while remote notifications ensured users were informed even when away from home. However, the project encountered challenges, including occasional network connectivity issues that disrupted communication between the ESP32 and the smartphone application. Addressing these issues could improve system reliability, expand the range of sensors, and incorporate advanced data analytics. In conclusion, the IoT-based smart home automation system demonstrated its feasibility and effectiveness by integrating various sensors and actuators to provide comprehensive control and monitoring capabilities.

Fugure.15 LCD display for temparture and humidity sensor

Figure.15 LCD display for IR sensor and GAS sensor

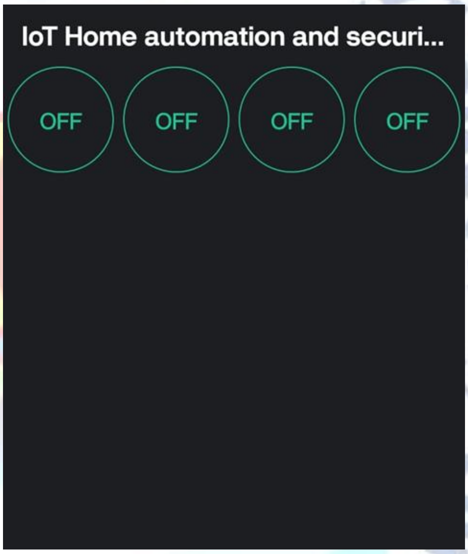

Fig. 17. Developed user interface for switching using Virtuino

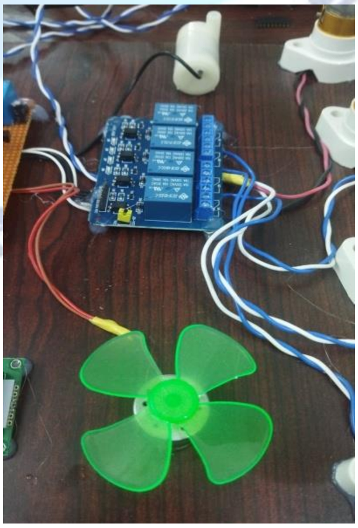

Fig. 18 Relay board operation for load protecting

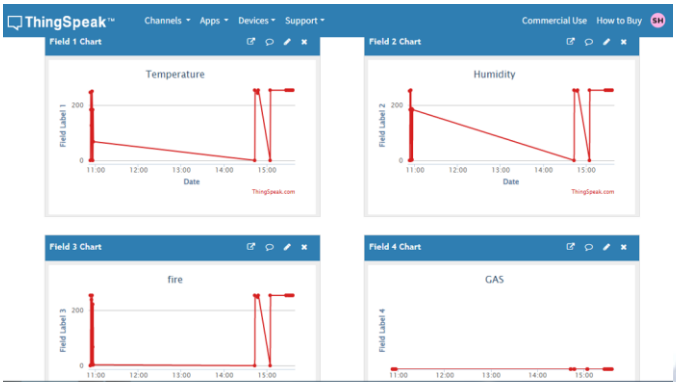

Fig. 19 Condition of humidity, temperature, fire and gas at home

6. CONCLUSION

In conclusion, the implementation of this IoT-based smart home automation system demonstrates significant advancements in home management and automation technology. By leveraging the ESP32 microcontroller and integrating a diverse array of sensors and actuators, the system provides robust functionality for monitoring and controlling various aspects of a home environment. Users can remotely manage lighting, appliances, and environmental conditions through intuitive interfaces, enhancing both comfort and energy efficiency. The system's capability to detect and respond to environmental changes, coupled with its real-time feedback mechanisms via the LCD display and audible alerts from the buzzer, ensures proactive management of home security and safety. Future enhancements could focus on expanding sensor capabilities, optimizing energy usage algorithms, and further enhancing user interfaces to meet evolving smart home demands. Overall, this system represents a significant step towards creating smarter, more responsive homes that cater to modern lifestyle needs.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] W. A. Jabbar, M. Ismail, and R. Nordin, "Evaluation of energy consumption in multipath OLSR routing in Smart City applications," in Communications (MICC), 2013 IEEE Malaysia International Conference on, 2013, pp. 401-406.

[2] K.-M. Lee, W.-G. Teng, and T.-W. Hou, "Point-n-Press: An Intelligent Universal Remote Control System for Home Appliances," IEEE Transactions on automation science and engineering, vol. 13, pp. 1308-1317, 2016.

[3] P. P. Gaikwad, J. P. Gabhane, and S. S. Golait, "A survey based on Smart Homes system using Internet-of-Things," in Computation of Power, Energy Information and Communication (ICCPEIC), 2015 International Conference on, 2015, pp. 0330-0335.

[4] W. A. Jabbar, M. Ismail, and R. Nordin, "MBA-OLSR: a multipath battery aware routing protocol for MANETs," in Intelligent Systems, Modelling and Simulation (ISMS), 2014 5th International Conference on, 2014, pp. 630-635: IEEE

[5] T. Song, R. Li, B. Mei, J. Yu, X. Xing, and X. Cheng, "A privacy preserving communication protocol for IoT applications in smart homes," IEEE Internet of Things Journal, vol. 4, pp. 1844-1852, 2017.

[6] D. Acharjya, M. K. Geetha, and S. Sanyal, Internet of Things: novel advances and envisioned applications vol. 25: Springer, 2017.

[7] R. Piyare and M. Tazil, "Bluetooth based home automation system using cell phone," in Consumer Electronics (ISCE), 2011 IEEE 15th International Symposium on, 2011, pp. 192-195.

[8] W. A. Jabbar, M. Ismail, R. Nordin, and S. Arif, "Power-efficient routing schemes for MANETs: a survey and open issues," Wireless Networks, pp. 1-36, 2016.

[9] S. Wu, J. B. Rendall, M. J. Smith, S. Zhu, J. Xu, H. Wang, et al., "Survey on prediction algorithms in smart homes," IEEE Internet of Things Journal, vol. 4, pp. 636-644, 2017.

[10] O. T. Algoiare, "Design and implementation of intelligent home using gsm network," 2014.

[11] R. Kazi and G. Tiwari, "IoT based Interactive Industrial Home wireless system, Energy management system and embedded data acquisition system to display on web page using GPRS, SMS & E-mail alert," in Energy Systems and Applications, 2015 International Conference on, 2015, pp. 290-295.