IoT – Supervisory Living Space Automation

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Abstract – For Automated Control and Real – Time Monitoring, a system is needed with cutting edge technology that not only provides alerts to users but also makes decisions and renders the output based on certain conditions. One such system is the IoT Supervisory Living Space Automation System that integrates an ESP-32 controller with many sensors for automated control and real-time monitoring. Using sensors like, but not limited to, DHT11, PIR, MQ-5, soil moisture, rain, and ultrasonic sensors, the system monitors the environmental for safety. This data is processed that allows for effective control of the environment and take necessary steps for irrigation, lighting, temperature, and security in order to prevent the vulnerabilities. The traditional system uses Arduino and external Wi-Fi to communicate with the user. As opposed to the traditional systems, the put forward system makes use of built-in Wi-Fi to enhance the connectivity, speed, and scalability of the system. The technology operates autonomously, diminishing the need of human interaction for actions and improving safety by providing immediate alerts for things like gas leaks and motion detection. The results show optimized speed, energy efficiency and dependability. Ultimately, the put forward system provides a flexible, creative, and easy-to-use solution appropriate for both existing smart living environments and future Internet of Things applications.

Keywords – IoT, Smart Home Automation, ESP – 32, Sensors, Real-Time Monitoring, Home Automation, Wireless Communication, Smart Living, Embedded Systems, Safety Alerts.

I. INTRODUCTION

On account of accelerated growth of IoT and to make the living of humans safe and easy, an environment was developed where users can control their environment with just some commands sitting in their comfortable place either in house, or outside the house. This environment has multiple devices linked with each other and monitored by a master, forming a smart environment called the IoT-based smart environments. This system had enhanced user comfort, facilitated remote access, and increased efficiency only made possible by home automation [1-2]. With the objective of making an autonomous system and monitor parameters like lighting, temperature, and security, in real – time, these systems use sensors, actuators, and communication technologies [3]. What makes this system more user friendly to engage are the smartphones, online apps, and voice-activated interfaces, providing smooth and practical control of appliances [4-5]. To get an efficient automation from a smart home system, the sensing, communication, and control layers must work together. Actuators collect and process real-time environmental data, such as temperature, motion, and gas levels, before controllers take the appropriate action. [6-7]. For achieving reliable connectivity between devices and users, communication technologies like Wi-Fi, Bluetooth, and GSM, are implemented that enables remote monitoring and control from any location [8-9]. Additionally, these systems strengthen safety among which are intrusion detection, fire warnings, and real-time surveillance, and by analyzing human usage patterns and ambient variables, these systems help to conserve energy, contributing to environmental conservation [10-11]. The system capacity and connection are furthermore enhanced with the Artificial intelligence and speech assistants [12]. Nevertheless, smart living systems grapple with challenges, mainly with compatibility limitations, security concerns, and reliance on stable network access. [13-14]. Data Tracking is another vulnerability brought up by ongoing data exchange [15]. The new era approaches to the mentioned setbacks emphasize on scalable and safe methods that use machine learning and edge computing, allowing for accelerated processing and better decision making [16-17]. As recent advancements in IoT supports the progress of smart cities and safe, sustainable living environments, the contemporary smart systems emphasize on user – friendly interfaces and real-time monitoring for enhancing the accessibility [18-19]. With the rapid growth of connected devices, the need for a robust and capable automation systems is advancing, highlighting the importance of this field for ongoing research and development. [20-21]. In IoT-based living spaces, supervisory control methods are crucial because they allow for intelligent coordination and central control of several subsystems, including lighting, temperature, and security. These systems guarantee effective and optimum performance by processing data in real-time, and their ability to react and overall efficiency are further enhanced by the use of cloud and edge computing [22-23]. Furthermore, interoperability frameworks provide easy connection between various devices, and AI-based predict automation enables systems to

understand user behaviour and modify processes automatically [24-25]. These advancements show how important supervisory control is to the creation of next-generation intelligent living environments [26].

II. RELATED WORK

IoT-based smart environments that allow for automation, monitoring, and intelligent control of living spaces are the subject of recent research [27]. By recognizing usage patterns and facilitating adaptive system operations, the integration of artificial intelligence with IoT increases energy efficiency [28]. Additionally, fog computing uses machine learning techniques to improve security, guaranteeing dependable data processing and safe communication [29]. Additionally, by processing data closer to the source, edge computing lowers delay and increases real-time response time, improving overall system performance [30-31].
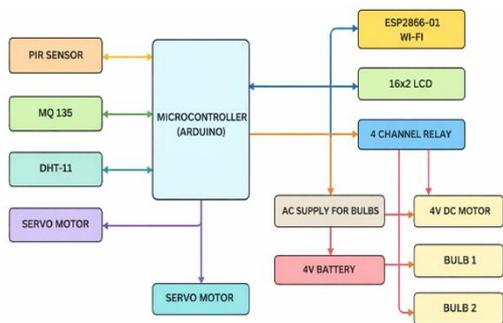
III. EXISTING SYSTEM

Fig. 1: Block diagram of Existing IoT – Based Smart Home System [32]

The block diagram of the existing IoT-based smart home system is shown in Fig. 1 In this system human involvement is necessary to operate switches or devices. The MQ-135 and DHT11 sensors assess humidity, temperature, and air quality, while the PIR sensor detects motion. The system uses sensors to monitor human presence and environmental variables. After processing the data, the Arduino sends updates via the ESP8266 Wi-Fi module and shows it on the LCD. A 4-channel relay, which serves as an actuator to control devices like lamps and motors, is used to control appliances based on both sensor data and user input, making the system semi-automatic [32].
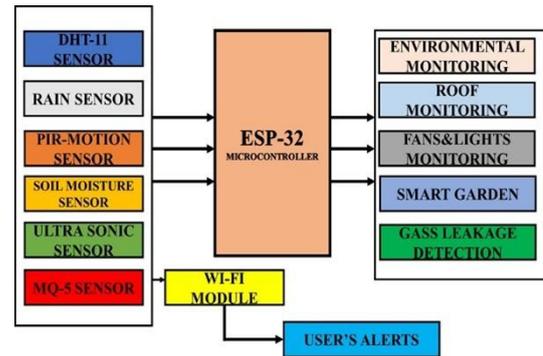
IV. PROPOSED SYSTEM

Fig. 2: Proposed Block diagram of ESP – 32 based Multi – Sensor Automation System

Fig. 2 presents the proposed block diagram of the ESP-32 based multi-sensor automation system. An ESP-32 based IoT smart monitoring and automation system utilizes sensors such as DHT11, rain, PIR motion, soil moisture, ultrasonic, and MQ-5 to collect real-time environmental and safety data. In order to carry out tasks like environmental monitoring, roof monitoring, fan and light control, smart gardening, and gas leak detection, the ESP-32 processes this data and connects via Wi-Fi. When a person is spotted using the PIR sensor, the system can be controlled, but otherwise it runs automatically without human involvement. It also offers user warnings to make sure efficiency, safety, and real-time monitoring.

A. Methodology / Principle of Operation

The proposed IoT-Supervisory Living Space Automation system gathers real-time data from actuators, namely but not limited to DHT11, rain, PIR, soil moisture, ultrasonic, and MQ-5 and delivers it to the brain which is the ESP – 32. The ESP – 32 analyses the collected data and renders decisions driven by certain conditions. The rendered decision may include controlling water pumps, lights, fans, and alarms, anyone or all simultaneously. Furthermore, the system enables real – time monitoring and user notifications for reducing danger via Wi – Fi. Consequently, the system serves as an intelligent, automated, and safe living environment automation solution.

B. Hardware Implementation and Alert Mechanism

The ESP – 32 microcontroller is the core of the system, acting as brain of the system and connecting various actuators namely lights, pumps, and relays for delivering the output. The system also features multiple sensors including but not limited to the DHT11, PIR, soil moisture, rain, ultrasonic, and MQ – 5, which acts like the input actuators. With the help of Wi-Fi connectivity, the ESP – 32 processes the input actuators data and controls the connected devices based on surrounding environmental conditions without any human input. The system is designed and programmed to notify individuals when unexpected events, as examples the gas leakage, unrecognized motion, or significant environmental changes, takes place. Alerts to the individuals are delivered

through notifications, alarms, or display messages, ensuring safety while enabling real – time monitoring.

C. Power Supply and System Requirements

For ensuring a dependable and unblemished performance, the automated system is powered with a regulated supply of 5V while the ESP – 32 is powered with 3.3V. Alongside the ESP – 32, the automated system stands in need of numerous sensors, a relay module, the Arduino IDE, and Wi-Fi connectivity for programming, data transfer, and vital alert communication in real – time.

V. RESULTS AND DISCUSSION

Fig. 3: Hardware Prototype of IoT – Supervisory Living Space Automation

The Fig. 3 depicts a hardware prototype of a living space that is automated with the Internet of Things making it a smart living space. It displays a model of a miniature house with a microcontroller, sensors, and connecting wires to aid with real-time operation. Additionally, a solar panel is installed making the system more efficient and eco – friendly. The prototype is broken up into multiple sections. Each section represents a distinct space where the basic needs like the water and lighting management, can be portrayed being automated with ease. The prototype also portrays a real-world scenario where the Internet of Things can be used for home automation turning a regular home into a smart home.

Fig. 4 displays the output model of the IoT-based smart living space automation system. For real-time operation, a microcontroller, sensors, and relay modules are combined into a small housing. Basic automation features, including lighting control, can be seen by the model. It confirms that the suggested smart home system is implemented correctly.
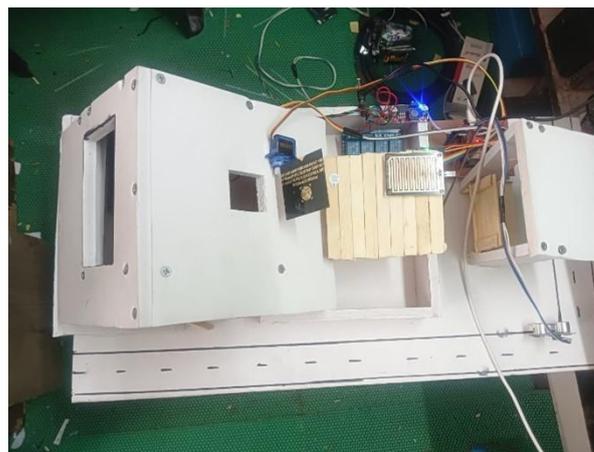

Fig. 4: Output model of IoT – Supervisory Living Space Automation

TABLE I: Sensor Performance and Observations [24-25]

Sensor	Parameter Measured	Observed Output	System Action
DHT11 [24]	Temperature & Humidity	28°C, 65% RH	Fan turned ON
PIR Sensor [24]	Human Motion	Motion detected	Lights turned ON
MQ-5 [25]	Gas Leakage	Gas detected	Alarm activated
Soil Moisture [25]	Soil Condition	Dry soil	Water pump ON
Rain Sensor [25]	Rain Detection	Rain detected	Roof system activated
Ultrasonic [25]	Distance/Object	Object detected (short range)	Alert / Monitoring triggered

The operation of the various sensors in the smart automation system is shown in Table I. Every sensor measures a certain parameter and, depending on the result, performs an action. While the PIR sensor activates lights when motion is detected, the DHT11 uses temperature and humidity data to drive the fan. When it finds a gas leak, the MQ-5 sounds an alarm. The rain sensor regulates the roof system, while the soil moisture sensor controls irrigation. The ultrasonic sensor aids in monitoring and object detection [24-25].

A comparison of the proposed and existing systems is shown in Table II. The existing system has limits in terms of sensor connection and scaling, operates semi-automatically, and is built on an Arduino with an external Wi-Fi module. The suggested system, on the other hand, makes use of an ESP-32 controller with integrated Wi-Fi, which allows for completely self-sufficient control, support for several sensors, and quicker performance with real-time warnings. All things considered, the proposed approach provides more scalability, better connectivity, and increased efficiency, which makes it more appropriate for current IoT-based smart living applications.

TABLE II: Comparison Between Existing and Proposed System

Feature	Existing System	Proposed System
Controller [6][24]	Arduino + ESP8266	ESP-32 (built-in Wi-Fi)
Automation [3][24]	Semi-automatic	Fully automatic
Sensors [3][24]	Limited sensors	Multiple sensors
Connectivity [6][24]	External Wi-Fi module	Inbuilt Wi-Fi
Performance [28]	Moderate	Faster and efficient
Alerts [24]	Basic alerts	Real-time alerts
Scalability [24][28]	Limited	Highly scalable

VI. CONCLUSION

The proposed IoT-Supervisory Living Space Automation system, which makes use of an ESP-32 controller with integrated Wi-Fi and several sensors, clearly improves the current system. It allows for efficient control of home appliances, real-time monitoring, and fully automated operation. By providing quick alerts, the system increases safety, and its quicker processing speeds up overall efficiency. In summary, this approach guarantees an ingenious, scalable, and reliable solution that improves regular smart living experiences.

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