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Research Article

An IoT-assisted Intelligent Monitoring System

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Abstract

Objective: The usage of power and automated control systems can save energy, but creating an intelligent control system via the Internet of Things (IoT) is an advanced technique because it provides remote access and control through the Internet, especially for those who are facing issues with monitoring their home's smart gears remotely. In this sense, NodeMcu is an internet-enabled device that operates under different conditions to monitor smart home gear securely.

Methods: Therefore, this research has been conducted to provide a solid platform for remote home control and monitoring, together with a complete solution. In this research, we have built a small model by integrating hardware components and connecting online to Google Firebase, allowing the end-user to monitor and control their online home environment efficiently.

Results: The online interface helps end-users care for their home equipment, lock doors, and install all intelligent gear inside smart homes. This interface ensures efficient and seamless interaction with all integrated smart home devices, enhancing the user experience and providing a higher level of convenience and security. Through this platform, end-users can perform a wide range of tasks such as adjusting lighting, regulating temperature, monitoring security cameras, and managing energy consumption. The system's user-friendly design and reliable connectivity ensure that users can maintain control over their home environment from any location with internet access.

Conclusion: The proposed model is Cost effective, making it accessible to a boarder demographic. This advancement in home automation enhances security and improves the overall management of smart home system.

Keywords: smart home, remote monitoring, internet, Google firebase, NodeMcu, power

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1 INTRODUCTION

The era in which we live is called the era of technology because things are dramatically changing with each passing day. For example, we have mobile phones for talking, automobiles for traveling, and many other things due to rapid technological innovations. Have you ever considered smart home automation that allows you to control individual appliances? Sometimes, we must remember to turn off our appliances in a hurry. On the other hand, if we think about those countries, power is a significant issue; in that case, we have to go somewhere to switch off some appliances. Some turn on because of power consumption, or a short circuit issue might occur, which is severely dangerous for our homes. If these appliances become alerted to our smartphones and we forget the switch-on/off activity, we can easily handle it[1]. Also, it is the same for those who work far away from their home and don't know that their home is safe from unauthorized and suspicious activities, so how can they be sure that it is safe? If the locks are connected to your mobile device, suspicious activities can be easily managed anywhere. In this regard, many organizations offer many types of intelligent home-related applications, but they are too costly, and many people cannot afford these facilities[2]. In that case, we are making it for those who wish to have robust smart home remote monitoring on their limited budget, offer solutions to their real-life problems, switch on/off power, check short circuits, lock homes, and efficiently check their home appliances[3]. Therefore, considering the facility mentioned above, the primary goal of this research is to create an IoT-based smart control and monitoring system for smart home appliances. We will develop such a system using various network-enabled devices like NodeMcu - a type of Internet of Things (IoT) controlled remotely over the Internet. We will use agile-scum methodology for the completion of such tasks.

The review highlighted the importance of sensors, actuators, data acquisition, processing units, and cloud-based platforms in enabling real-time data collection, analysis, and control. It discussed different architectural models and their advantages and limitations, including centralized, distributed edge computing, and hybrid architectures. In addition, it explored communication protocols such as MQTT, CoAP, and WebSocket, considering their scalability, reliability, and energy efficiency. IoT-based smart control and monitoring systems' applications span home automation, industrial control, agriculture, healthcare, and smart cities. Each application domain presents unique challenges and requirements that must be addressed for a successful implementation. However, several challenges and limitations remain. These include security and privacy concerns, interoperability issues, power consumption optimization, data management and analytics, and scalability. Overcoming these challenges is crucial for the widespread adoption and deployment of smart control and monitoring systems based on the IoT.

Despite these challenges, the benefits of IoT-based smart control and monitoring systems are significant. They offer increased efficiency, improved safety, decision-making, and cost savings in various sectors. As the IoT ecosystem continues to evolve and technologies advance, these systems are expected to become more sophisticated, reliable, and integrated into our daily lives. IoT-based intelligent control and monitoring systems have tremendous potential to revolutionize industries and improve our quality of life. More research, development, and standardization efforts are needed to overcome existing challenges and unlock this technology's capabilities.

1.1 Problem Statement

Sometimes, in a hurry, we forget to switch off the appliance, and if we talk about some countries where load shedding (shortage of electricity) is a major issue, and if we have to go somewhere and suddenly load shedding starts. We switch off all the lights, and after a few hours, we return home and see some appliances are still on, so why not? There is a system that gives you an alert when the electricity comes on, so you forget this thing. On the other hand, if you are far away from your home because of work and you're not sure about the safety of your home so, what if there's a feature in a system which, with the help of your browser, you can check once a day very easily.

1.2 Objectives

In hardware, we have an intelligent hub, NodeMcu, in which various devices are integrated to control specific appliances. On the online web, there's a state change option to prevent, which provides a user-friendly interface that helps. Our project aims to design an advanced IoT-based SCMS using hardware devices. They both work as transceivers and can operate their home in an automated way with just a single click.

2 SYSTEM ARCHITECTURE

The system architecture/system model or network model presented in this paper consists of many software and hardware entities/objects, as shown in Figure 1. Each of these, described one by one, is as follows:

Blynk: A small home model, network-enabled devices to control specific appliances of the home, and an Android application called Blynk, which enables network-enabled smart devices like Arduino and NodeMcu. This Android-based application provides the facility to build a graphical user interface for each home appliance in a reliable manner.

ESP8266 Wi-Fi: Applications for IoT are the main feature of this model, having relay functions capable of switching, isolating input/output activity, and cutting off the current.

NodeMcu: It is an inexpensive, open-source IoT

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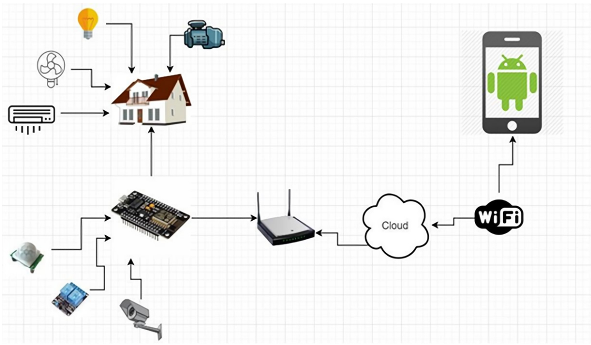

Figure 1. System architecture.

platform. Initially, it comprised hardware based on the ESP-12 module and firmware based on the ESP8266 Wi-Fi SoC from Empress of Systems. Later on, support for the ESP32 32-bit Mcu was introduced. It is the central control unit of the system based on the ESP8266 development board. It provides Wi-Fi connectivity and acts as the central processing unit for the system.

PRI Motion Sensor: This sensor detects motion in its surroundings. It can trigger specific actions when detecting motion, such as sending notifications or activating security measures.

Standard LCD: This component displays the system's results, such as sensor readings, status messages, or other relevant information.

Buzzer and LEDs: These components are used for audio and visual feedback, respectively. They can be used to indicate system states, alarms, or notifications.

Flame Sensor: The presence of flames or fire is detected by this sensor. It can be used to initiate emergency procedures, such as sounding an alarm or informing authorities.

Relays: These devices control appliances or devices connected to the system. They act as switches that can turn on or off the power supply to the appliances according to the instructions of the system.

Breadboards and jumper wires: These components are used to prototype and connect various electronic elements.

Buttons: Buttons provide a means for manual input or user interaction with the system. They can be used for system control or configuration purposes.

Camera: The camera is an additional hardware component that can be integrated into the system. It allows one to capture images or video footage, which can be used for surveillance or monitoring purposes.

3 CRITICAL LITERATURE REVIEW

The Internet of Things seeks to integrate all objects in our environment into intelligent virtual objects, enabling us to control and monitor the condition of these devices. This section discusses the relevant methods and literature on the scope of the study. In recent years, the home automation system has gained interest from researchers, as it helps us live comfortably and progressively improves our standard of living. Today, the appliances that make up a home automation system are monitored and managed by a smartphone that runs Android software. Research endeavors and contributions to advancements have been gathered for this specific problem; therefore, considering our motivation, this section describes other works in a tabular form, shown in Table 1.

The advancements in technology, particularly in micro/nano sensor technologies, have paved the way for the integration of Internet and communication technologies with smart sensing devices and physical objects. This integration has given rise to the IoT, which encompasses a wide range of applications across various sectors, including healthcare, transportation, and home automation. The proliferation of IoT has been fueled by the development of smart medical systems, which offer low-cost, noninvasive, and long-term continuous health monitoring solutions. These IoT-enabled medical devices, equipped with sensors and actuators, enable individuals to monitor their health data in real-time from any computer or mobile device, facilitating seamless integration with the healthcare system[1-9].

In the realm of home automation, IoT has revolutionized the way we interact with our living spaces. A multitude of IoT-based solutions have been developed for monitoring and controlling various aspects of the home environment, such as temperature, humidity, and electrical appliances. These solutions utilize a combination of hardware components, including microcontrollers (such as Arduino and NodeMCU), sensors (such as temperature and motion sensors), and communication modules (such as Wi-Fi and Bluetooth), to enable remote access and control of home devices and appliances[10-19].

The deployment of IoT in home automation has led to the emergence of smart homes, where residents can remotely monitor and manage their home environment using smartphones or other connected devices. Through the integration of IoT devices and platforms, homeowners can achieve greater convenience, energy efficiency, and security in their living spaces. Additionally, IoT-based home automation systems can provide valuable insights and alerts, allowing homeowners to optimize their energy usage, detect anomalies, and enhance their overall quality of life[21-26].

Overall, the widespread adoption of IoT in home automation signifies a paradigm shift in how we interact with our living spaces, offering unprecedented levels of convenience, efficiency, and control. As IoT technologies

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Table 1. Literature Survey

Ref	Year	Device Used	Hardware Technologies	Uses	Cost
[1]	2023	Android-based Smartphone	Arduino mega, ESP 8266, ATmega2560 microchip	Activity and gesture recognition, environment monitoring and control	Low
[2]	2018	Android-based applications, Wi-Fi modules, virtual mobile applications	Arduino Mega,Wi-Fi module ESP8266, relay board	Control electrical appliances, monitor home temperature and humidity	Low
[3]	2017	Mobile Phone, tablet, computer	ESP8266, Raspberry Pi boards	Management of fire system and electrical devices, security system, and medical guidelines	High
[4]	2020	Smart Phone	TI CC3200 launchpad, passive infrared motion detector sensor, Arduino UNO microcontroller	Face recognition system, home office security	Low
[5]	2020	Smartphone, android applications	NodeMCU Development board, ESP12E Module, ESP8266 NodeMCU pinout	Remote access, control appliances, and control security	Low
[6]	2019	Smartphone	NodeMCU, sensor, notification, server, Wi-Fi, Blynk	Electronic home appliances, human movement, and temperature sensors	Low
[7]	2018	Smart Phone	ATmega16, NodeMCU, ESP8266 Wi-Fi Module	Monitoring temperature and humidity, Status monitoring (ON / OFF control)	Low
[8]	2022	Any portable device	server (web server), sensors and actuator, Arduino UNO, NodeMCU	control multifarious home appliances, control the entire house lighting system	Low
[9]	2021	Smart Phone	ESP8266/ESP8285 chips, Raspberry Pi boards	Temperature control, motion detection, smartphone alert, alarm control	High
[10]	2020	Smart Phone, personal computer	Raspberry Pi Board, Light dependent Sensor, Rpi Camer Module, Rpi Camer Module	controlling devices and appliances remotely, door security, sense motions and humidity, and temperature	Low
[11]	2013	Android-based Smartphone	Micro-web server running on Arduino Uno	Home Gateway, Device control, Device Monitoring	Low
[12]	2016	Mobile phone	Microcontroller used is the TI-CC3200 Launchpad board	Wireless home security system	High
[13]	2021	Mobile Phone	ESP8266/ESP8285 chips and/or on Raspberry Pi boards	Control of home appliances and sensors	Low
[14]	2018	Smart Phone	NodeMCU-ESP8266 microcontroller board	Thermal comfort, visual comfort (colors & light), and hygienic comfort	Low
[15]	2017	Smart phone/ laptop/tablet	ARM-11 architecture, Raspberry Pi-3 board, USB camera	Security and surveillance to home through the internet	Low
[16]	2016	Smartphone	Microcontroller, ZigBee, Wi-Fi, Bluetooth, EnOcean and GSM	Control and monitor the home appliances	Low
[17]	2011	Smart Phone	Wireless sensor nodes, ZigBee protocols	Wireless monitoring system for building smart room architectures	Low
[18]	2015	Any portable device	Zigbee, WiFi, Raspberry pi	Lights, fan, door lock remotely controlled, fire alarm with alert message & image sent to smartphone	Low
[19]	2015	Smart Phone	Delta DVP28SV model PLC	Control of the ventilation, lighting and security units	High
[20]	2019	Smart Phone	Micro web server based on an Arduino Yún microcontroller	Light switches, power plugs, and various sensors, including temperature, gas, and motion sensors	Low
[21]	2022	Smart phone	WiFi enabled Micro Controller	Smart thermostat, Smart lighting, Smart Locks, Sensors	Low
[22]	2020	Smart phone	Raspberry Pi, Color Sensor (TCS3200), Channel Relay, Arduino	Wireless sensor and actuator network, smart meters, smart buildings. Wireless sensor and actuator network, smart meters, smart buildings. Wireless sensors, Actuator network, smart meters	High
[23]	2019	Smart Phone	NodeMCU,. ESP8266 NodeMCU , ESP8266 NodeMCU . ESP8266, NodeMCU ESP8266, RF 433 MHz WSAN, ARMII Rasberry Pi	Sensors, GSM, RFID	High

[24]	2018	Smart Phone	KNN Algorithm, automation control microcontroller.	IR sensors,with Bluetooth controller, Android mobile device, IR transmitter	Low
[25]	2018	Smart Phone	Arduino Mega microcontroller, Virtuino mobile application	Sensors, Relays, Battery	Low
[26]	2017	Smart Phone	Frugal Labs IoT Platform, Logic Gates	Sensors, fan, door lock remotely controlled	Low
[27]	2018	Smart Device	Arduino Mega, Virtuino mobile application, HAS, Low cost WIFI	Electric Appliances, Wireless LAN, Microcontrollers, Intelligent sensors, Temperature sensors	Low

continue to evolve, the possibilities for smart home applications are boundless, promising to further enhance the way we live, work, and interact with our surroundings[27].

4 SOLUTION

The design of the system for the IoT-based smart control and monitoring system can be divided into several components. Here is a high-level overview of the system design:

Hardware Components: The hardware components, including the NodeMCU, motion sensor, LCD, buzzer, LEDs, flame sensor, relays, buttons, and camera, are interconnected to form the physical infrastructure of the system. They are integrated using breadboards and jumper wires for prototyping and circuit connections.

Power Supply: The design of the system should include a suitable power supply mechanism to provide power to the hardware components. This can involve the use of batteries, adapters, or a combination of power sources depending on specific requirements and deployment scenarios.

Communication: The NodeMCU, equipped with Wi-Fi connectivity, facilitates communication between the system and external entities. It enables data transmission, remote control, and monitoring capabilities. Communication can be established through local Wi-Fi networks or through the Internet, allowing access from remote locations.

Sensor Integration: The sensors such as the motion sensor and flame sensor are connected to the NodeMCU to detect motion and flame, respectively. The NodeMCU reads the sensor data and processes them for further action.

User interface: The LCD, LEDs, and buzzer are used to provide a user interface for system feedback and notifications. The LCD screen can display sensor readings, system status, or messages, while LEDs and the buzzer can be used to provide visual and audio alerts to users.

Control and Automation: The NodeMCU controls the relays based on input from sensors or user commands. It activates or deactivates the relays to control the connected devices or appliances. The control logic can be programmed using the Arduino IDE and uploaded to the NodeMCU.

Data Processing and Decision Making: The software components running on the NodeMCU process the sensor data and make decisions based on predefined rules or user-defined instructions. For example, if motion is detected, the system may trigger an alarm, send a notification to the user's mobile device, or activate surveillance through the camera.

System Integration: System design should consider integration with other devices or platforms, such as mobile or web applications, to enable remote access, data storage, and analysis. This integration can be achieved through APIs, cloud services, or custom protocols.

Security: The design of the system should incorporate security measures to protect against unauthorized access or tampering. This can involve encryption, authentication mechanisms, and secure communication protocols to ensure the system's integrity and user privacy.

Scalability and Flexibility: The design of the system should be scalable and flexible to accommodate future expansions or modifications. It should allow for the addition of new sensors, devices, or features without significant changes to the overall architecture.

Deployment and Installation: The design of the system should consider physical deployment and installation requirements, ensuring that the hardware components are properly positioned and connected. It should also provide guidelines for software setup and configuration.

Bluetooth Module: The purpose of the Bluetooth module app in this project is to provide a wireless communication interface between the IoT-based smart control and monitoring system and a mobile device (such as a smartphone or tablet) that has Bluetooth capabilities. The Bluetooth module enables the following functionalities:

Real-Time Monitoring: The app can receive real-time data and sensor readings from the IoT system through the Bluetooth module. Users can view the status, measurements, and alerts generated by various sensors (such as motion sensors, flame sensors, or environmental sensors) through the app.

Notifications and alerts: The Bluetooth module app can

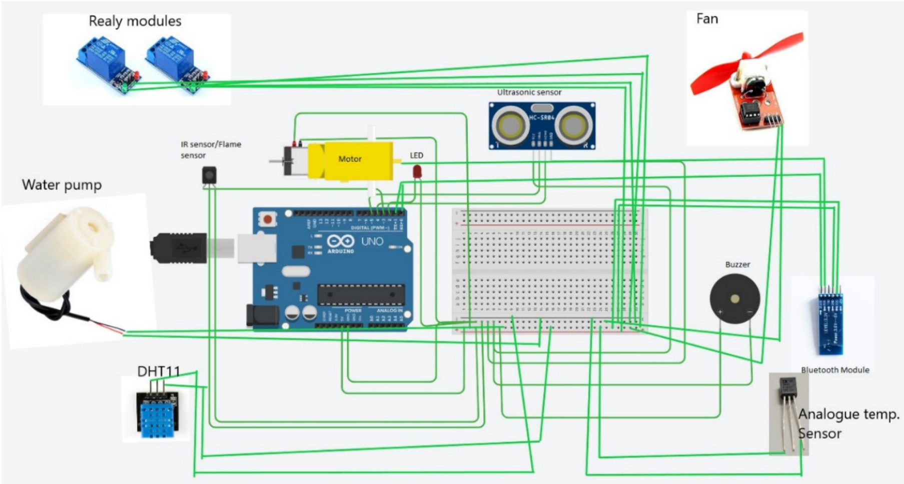

Figure 2. Circuit diagram.

send notifications and alerts to the user's mobile device based on events or conditions detected by the IoT system. For example, if the motion sensor detects movement in the house or if the flame sensor detects a fire hazard, the app can immediately notify the user.

Data Logging and Analytics: The Bluetooth module app can collect and log data from the IoT system, including historical sensor readings, energy consumption, and other relevant metrics. Users can access and analyze these data through the app, enabling them to identify patterns, trends, and optimize their energy usage.

5 DISCUSSION

Overall, the Bluetooth module app acts as a bridge between the IoT-based smart control and monitoring system and the user's mobile device, enabling wireless control, real-time monitoring, notifications, configuration, and data analysis. It adds mobility and convenience to the user experience, allowing users to interact with the system from anywhere within the range of the Bluetooth connection. (Figure 2)

Light, Water Motor, and Fan: Each device (light, water motor, and fan) is connected to a separate relay. The relay is connected to the NodeMCU board. The purpose of the relay is to control the power supply to each device. When the relay is triggered, it can turn the respective device on or off.

Flame Sensor: The flame sensor is connected to the NodeMCU board and the breadboard. It typically requires two connections: Voltage at the common collector (VCC) and Ground (GND). The flame sensor output pin is connected to a digital input pin on the NodeMCU board. The flame sensor detects the presence of flames and sends a signal to the NodeMCU board for further processing.

Ultrasonic Sensor: The ultrasonic sensor is connected to the NodeMCU board and the breadboard. It usually requires power supply connections (VCC and GND) and two signal connections: Trigger and emulation. The trigger pin sends a signal to initiate the measurement. The echo pin receives the reflected signal and calculates the distance based on the time taken. The ultrasonic sensor measures distances and can be used for various applications, such as proximity detection.

Obstacle Detector: The obstacle detector is connected to the NodeMCU board and the breadboard. A specific connection may depend on the type of obstacle detector used. It typically requires power supply connections (VCC and GND) and a signal connection to a digital input pin on the NodeMCU board. The obstacle detector detects obstacles in its range and sends a signal to the NodeMCU board when an obstacle is detected.

Bluetooth Sensor Module: The Bluetooth sensor module is connected to the NodeMCU board. A specific connection may vary depending on the module used. It typically requires power supply connections (VCC and GND) and connections for data transmission, such as TX and RX pins. The Bluetooth sensor module allows communication between the NodeMCU board and external devices, such as a mobile phone or tablet, using Bluetooth technology.

Buzzer: The buzzer is connected to one of the relays. When the relay controlling the buzzer is triggered, it provides power to the buzzer, producing sound or an alarm. The buzzer can be used to provide audible alerts or notifications based on certain conditions or events.

6 FUTURE DIRECTIONS

The IoT device business has undergone major transformations in just a few short years. From a situation of fragmented devices and no ecosystems at all, the industry has developed to include corporate organizations working together to establish ecosystems optimized for mobile technology, allowing IoT devices to become networked.

The idea of automated systems may have seemed bizarre and impossible at first, but as our gadgets become smarter and more money is invested in developing IoT consumer items, we should expect increased competition to stimulate greater innovation in the field.

If you are searching for solutions to improve the convenience and safety of your workplace, automation systems are something to take into account. Technology may simplify your life, whether you use it often or only a few times. Depending on the size of the project, automation systems might have a high upfront cost. In the future, the field of IoT based smart control and monitoring systems is expected to undergo significant advancements and innovations. Here are some potential areas of development:

(1) Enhanced Connectivity: IoT devices will continue to leverage faster and more reliable connectivity technologies, such as 5G, that enable seamless communication and real-time data exchange between devices. This will result in more responsive and efficient control and monitoring systems.

(2) Edge Computing: With the growth of IoT devices, there will be a growing emphasis on data processing and analysis at the network's edge. Edge computing will reduce latency, enhance security, and enable faster decision making by bringing computation and analytics closer to the devices themselves.

(3) Artificial intelligence and machine learning: AI and machine learning algorithms will play a crucial role in IoT-based systems. They will enable predictive maintenance, anomaly detection, and intelligent automation. These technologies will continuously learn from the data generated by IoT devices to optimize control and monitoring processes, improve energy efficiency, and reduce downtime.

(4) Integration with blockchain: Blockchain technology can enhance the security, privacy, and trustworthiness of IoT systems. It can facilitate secure transactions, enable device identity management, and establish transparent and auditable data exchanges. Blockchain-based solutions will play an important role in sectors such as supply chain management, energy grids, and healthcare.

(5) Environmental Monitoring: IoT-based systems will increasingly focus on environmental monitoring to address climate change and sustainability challenges. The sensors embedded in the devices will monitor air quality, water resources, energy consumption, and other environmental parameters. These data will be used to optimize resource allocation, develop predictive models, and support environmentally friendly decision making.

(6) Enhanced Human-Machine Interfaces: IoT systems will feature intuitive and interactive interfaces, including voice commands, augmented reality, virtual reality, and gesture recognition. These interfaces will improve user experience and make the monitoring and controlling systems more accessible and user-friendly.

(7) Integration of Wearable Devices: The integration of IoT devices with wearables will allow for personalized monitoring and control systems. For example, smartwatches and fitness trackers will collect data on an individual's health, sleep patterns, and activity levels, which can be used to provide tailored recommendations, optimize energy usage, and enhance overall well-being.

(8) Industry-Specific Solutions: IoT-based control and monitoring systems will continue to evolve to meet industry-specific needs. Industries such as agriculture, manufacturing, transportation and healthcare will develop specialized solutions to monitor and control processes, improve efficiency, and reduce costs.

(9) Data Security and Privacy: As IoT devices become more ubiquitous, ensuring data security and privacy will be paramount. Advanced encryption techniques, secure communication protocols, and robust access control mechanisms will be implemented to protect sensitive data and protect against cyber threats.

(10) Standardization and Interoperability: Efforts will be made to establish industry-wide standards and protocols to promote interoperability and facilitate the seamless integration of diverse IoT devices and systems. Standardization will enable different devices to work together, promoting scalability, flexibility, and a more unified IoT ecosystem.

It is important to note that the future of IoT-based smart controlling and monitoring systems is highly dynamic, and new technologies and trends may emerge over time, further shaping the landscape of this field.

7 CONCLUSION

A home automation system will monitor and/or operate many aspects of the home, such as lights and appliances. Home security systems such as access control and alarm systems may also be included. The term "smart home" refers to internet-connected home automation devices. Home automation, as a broader category, encompasses any item that can be monitored or controlled wirelessly, rather than only those with internet connectivity. When connected to the Internet, home sensors and activation devices contribute significantly to the IoT. Go for it if you have a small budget for a little exploration. Consider self-care, as it can improve your quality of life.

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Conflicts of Interest

The authors declared no conflict of interest.

Author Contribution

Afzaal R was responsible for conceptualizing, developing methodologies, investigating and supervising the project.

Hussain S was responsible for paper writing and revisions.

Abbreviation List

GND, Ground
IoT, Internet of Things
VCC, Voltage at the common collector

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