Section A-Research Paper
ISSN 2063-5346

IoT-Based Automation System for Smart Homes: Design and Implementation

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Abstract

Home Automation Systems (HAS) are becoming more and more common as a result of developments in communication technology. These systems are a part of Internet of Things (IoT) applications, allowing users to automate the remote operation of their home appliances. In this study, a low-cost Wi-Fi-based automation system for Smart Homes (SH) is proposed. This system enables remote monitoring and control of household appliances through an Android-based app. The fundamental component of the automation system is an Arduino Mega microcontroller with a Wi-Fi module. The system's flawless integration into the home network is made possible by this configuration. Multiple sensors are used to keep track of things like temperature, humidity, and motion in the home environment. To provide the best possible control and management of the household, these sensors provide useful data.A relay board is used to create a connection between the home's appliances and the home automation system. The connected appliances may now be operated precisely and under control thanks to this integration. The suggested automation system offers a simple and effective way to remotely operate electrical appliances inside the home by utilising Wi-Fi and the Virtuino mobile application. This study offers a viable and affordable method for integrating home automation systems into smart homes. Thanks to the Android-based application and Arduino Mega microcontroller at the heart of the system, homeowners can effortlessly monitor and operate their home appliances with simplicity through the integration of Wi-Fi technology and numerous sensors.

Keywords:Home Automation Systems, Internet of Things, Smart Home, Android

1. Introduction

The growing use of smart gadgets with sensors and wireless connectivity in recent years has accelerated the development of the Internet of Things (IoT). The IoT is now a key factor in raising living standards and advancing the world economy. It makes it possible for physical items to be seamlessly connected throughout the globe, including sensors, RFID, cellphones, cars, and appliances, to work together intelligently and independently to meet people's needs.Connecting and managing numerous "things" via the Internet is the overarching goal of the IoT.

This vision has led to the development of a wide range of IoT application domains, including smart cities, smart homes, smart grids, smart transportation, smart healthcare, industrial automation, and surveillance. Due of its direct influence on

people's daily lives, the design of Smart Homes (SH) has attracted the most attention of these applications from both the academic and industrial sectors.Different definitions exist for a "smart home," but a typical one characterises it as a house with an automated system made up of sensors and device controllers. The goal is to build a cosy, knowledgeable, and safe environment that improves quality of life and makes controlling household appliances easier. For older and disabled people who would struggle with standard home systems, this is very helpful.An interface between cellphones or personal computers and household appliances is provided by the Smart household automation system, as shown in Figure 1. Through wireless communication interfaces like Bluetooth and Wi-Fi, this connectivity is made possible. Users can effortlessly interact with and operate their home appliances thanks to the integration of various technologies, which improves the entire smart home experience.

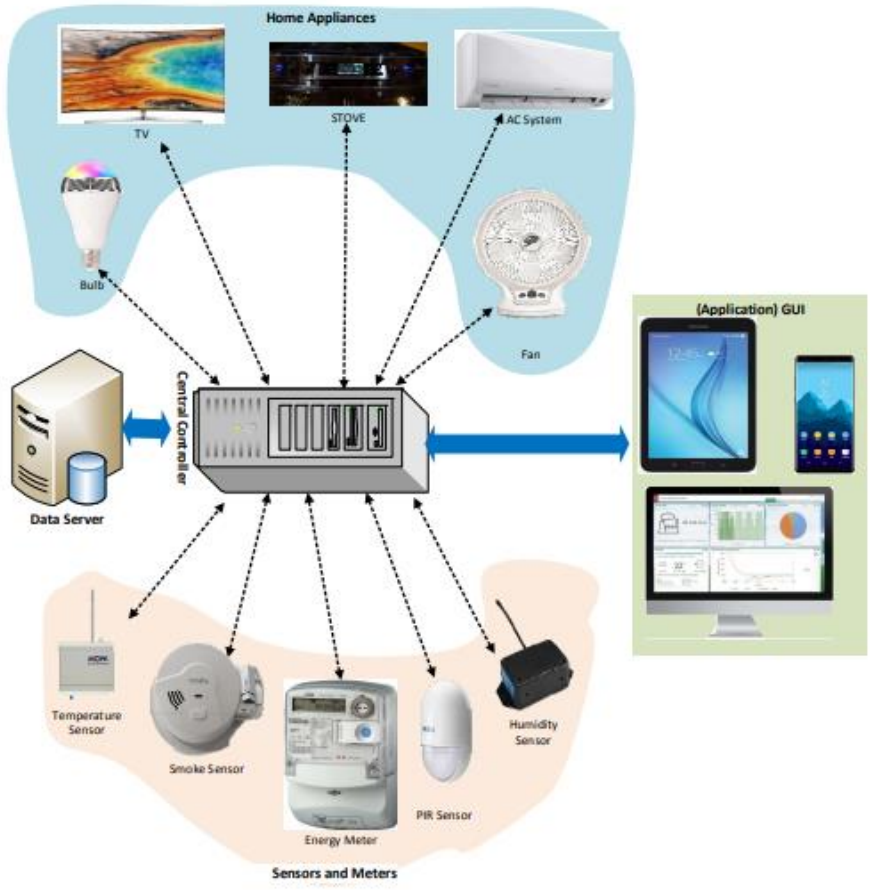

Fig 1 Smart home architecture

Locally controlled and remotely controlled systems are the two primary subcategories of home automation systems (HAS). via locally controlled systems, customers can operate their home appliances via a wireless or stationary in-home controller that uses Bluetooth, Zigbee, or GSM. On the other hand, remotely controlled systems let consumers manage their houses using their mobile devices or desktop computers and the Internet.The design of such automated systems must take into account a number of important factors. First and foremost, the system must

provide a user-friendly interface for simple installation, supervision, and management of home appliances. To fully utilise the promise of wireless technology, it must also guarantee a quick and dependable connection with adequate data rates and communication range. Finally, the system must be cost-effective in order to be used in home automation and be available to a wider audience.This study suggests an integrated strategy that blends locally and remotely controlled features to address these design issues and get beyond the limits of current home automation systems.

The suggested method enables local control with a Wi-Fi interface and a cheap Arduino microcontroller. Furthermore, it makes use of Internet of Things (IoT) principles for remote control, enabling customers to handle their appliances regardless of their location or mobile service provider. Users can now monitor, manage, and control their devices remotely via an IoT platform thanks to the integration, which also allows the system to work locally with Android-based smartphones through Wi-Fi.The essay is set up like follows: Background details on home automation systems are given in the next section, along with some of their benefits. An overview of the chosen technique and resources is provided in Section III. Section IV talks about how the suggested method will be put into practise. Section V presents the findings and a discussion of the system's performance. A summary of the successes and contributions of the integrated method for locally and remotely controlled home automation systems is provided in Section VI, which also serves as a conclusion.

2. Background

The Internet of Things (IoT) concept, where all gadgets and appliances are allocated an IP address, plays a vital role in home automation, also known as smart home technology. This enables remote monitoring and access from anywhere at any time. This smart device network's interconnectedness allows for complete control over many parts of the home.Home automation systems in the past mostly concentrated on straightforward functions like lighting and fundamental appliance management.

The concept of a linked world is now a reality thanks to technological breakthroughs that make it possible to fully control smart gadgets in the house. This implies that no matter where they are physically located, homeowners can remotely manage their smart appliances and devices.Users of home automation are given the ability to direct how gadgets should respond to specific triggers, stating the grounds and timing of their responses. Convenience, effectiveness, and potential cost savings are all benefits of this level of management. Additionally, by warning customers of probable occurrences like water leaks, gas leaks, fires, and unauthorised entrance to their houses even when they are away, home automation systems can act as a security mechanism.Users have the freedom to alter the automation system's settings in accordance with their tastes and needs.

They can adjust the system whenever they want using an Android application or other control tools, guaranteeing that it exactly suits their needs and wants.In conclusion, home automation technology has advanced tremendously and now provides a wide range of management and monitoring options for smart home devices. With this degree of automation, our houses become more intelligent and

responsive to our needs while also providing convenience, energy efficiency, cost savings, and improved security.The sophisticated lighting control system of smart home technology is one of its key advantages. Users are no longer need to manually turn on or off electrical appliances. For instance, when someone enters a bedroom, they have two options: either the lights turn on and off automatically when they leave the room, or the user can manage the switching via a smartphone app.

To cut down on power usage, the lights' brightness can also be changed.Additionally, customers have the choice to modify the room's temperature and humidity levels based on sensor readings. Through a smartphone application, they can alter the fan's speed or programme it to do so automatically based on the ambient temperature. electricity appliances are turned off when not in use thanks to this energy-efficient strategy, which results in significant energy savings and lower electricity costs.Another benefit is that consumers can use their smartphone, tablet, or laptop to remotely operate electrical appliances and check on the health of their homes. For instance, if the user leaves for work and forgets to turn off the fan, they can quickly do so with their smart device. Users can stay informed about potential risks at home by installing sensors for smoke, carbon monoxide, and floods.Users that care about security receive notifications on their phones in the event of any issues.

You can install motion sensors, and if any movement is noticed, the alarm will sound. This security system gives reassurance and aids in keeping the home safe from invaders. The likelihood of burglary can be greatly decreased by installing wired security cameras.Along with improving daily comfort, the integration of numerous smart home components, such as ventilation, heating, air conditioning, centralised lighting, controlled appliances, and security systems, also increases overall security. Smart Home technology provides convenience and safety, which enhances the quality of life for homeowners.The current Home Automation Systems (HAS) are hampered in their general adoption by a number of significant problems. The high implementation and maintenance expenses, which make them expensive for many users, are one serious worry.

Additionally, some existing systems allow users to observe their home's condition via a web application, which can be problematic for consumers since they must visit the internet each time they want to operate or monitor their home.A less intuitive user experience is also caused by the fact that many HAS lack user-friendly interfaces for monitoring and managing appliances. Additionally, some existing automation systems may have a limited selection of communication technologies. For instance, ZigBee's 250Kb/s data rate may not be enough for some applications, and Bluetooth's limited range of about 10 metres may not be enough either. Although GSM is available everywhere, it can be pricey, has slow data transmission speeds, and has limited coverage, especially in rural regions.The study suggests a novel solution to address these drawbacks and resolve the issues present in current home automation systems. An Arduino microcontroller and an Android-based smartphone will be used to build and create a low-cost Wi-Fi-based Automation System for Smart Homes.

With the help of IoT principles, this system aims to effectively control all of the home's electrical appliances and provide remote control.The suggested system attempts to provide a practical and affordable solution for smart home automation by utilising Wi-Fi technology and the widespread use of smartphones. In contrast to conventional web-based interfaces or constrained communication technologies, the combination of Wi-Fi and IoT capabilities enables customers to manage and monitor their appliances remotely. The ultimate objective is to overcome the pricing and usability issues that many existing systems encounter in order to make home automation realistic and approachable for a larger user base.

3. Methodology and Materials

A. Conceptual framework

The section on the conceptual framework as well as the methodology provides a comprehensive summary of the research approach as well as the many different stages that were employed in this study. In order to effectively fulfil the research aim, the strategy that will be used is designed to be methodical and well-organized. In this part, you will also find an in-depth explanation of how the proposed system's implementation features function, as well as an explanation of how the system's structural pieces collaborate with one another to accomplish the objective of the research. The multiple steps that the research study went through are visually depicted in the flowchart that can be seen in Figure 2. The flowchart also illustrates the sequential flow of activities and critical decision-making moments. This flowchart serves as a roadmap for grasping the development of the study as well as the logical order of steps performed to construct and test the recommended solution. It may be found here.

The conceptual framework that is presented in this part serves as the foundation for the study and provides the inquiry with a structure that is both understandable and well-organized. There is a discussion of the theoretical underpinnings of the research as well as the key concepts that will guide its further development and use. The methodology describes the study approach, the processes for acquiring data and conducting analysis, as well as the tools and technologies that were used in the process of developing the recommended system. In general, this part serves as a road map for the entirety of the research study. It paints a clear image of the research process, the integration of many different components, and the systematic technique that was utilised to effectively accomplish the research objectives and carry out the recommended system.

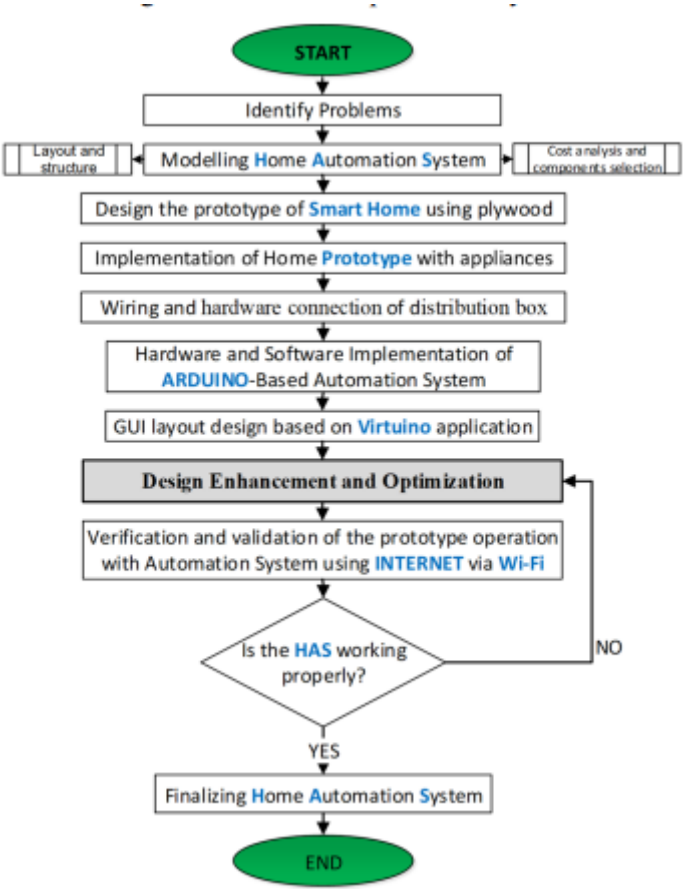

Fig 2 Flowchart of research activities

Figure 3 shows the home prototype's floor plan, giving a visual picture of how the smart home's fixtures and gadgets are positioned in the room. The layout design acts as a guide for the subsequent modelling phase, which employs all necessary tools and supplies to build the smart house prototype.The numerous components needed to build the smart home prototype are put together by the researchers or developers based on the layout design during the modelling phase. This could entail establishing the appropriate communication networks, integrating the smart appliances and gadgets, and setting up the physical infrastructure.A crucial stage in the development process, modelling brings the idea design to life and turns it into a tangible, workable prototype. It entails real application and hands-on labour to make sure that every component functions properly to accomplish the intended functionality and automation capabilities.The proposed system's performance and viability are assessed using the prototype as a testbed. It enables researchers to run practical simulations and observe user behaviour in order to spot any problems, fix them as needed, and confirm the efficiency of the smart home automation system.In general, the phases of layout design and modelling are crucial to the creation of the smart home prototype. They enable researchers to bring their ideas to life and build a functioning model for more experimentation and improvement since they provide a visual depiction of the imagined system and open the road for its actual realisation.

Fig 3. Plant layout

Plywood was used to construct the smart house prototype shown in Fig. 4. After that, wiring and hardware installation are completed. The Arduino Software's programming stage is then finished. Any issue that arises during project construction is found and fixed during the testing phase in order to improve and optimise the design. To prevent making the same mistake, several improvements are also made. Finally, the project's entire design is assessed.

Fig. 4 Top view of the house prototype

B. Main Components of Home Automation System

1) Arduino-The primary controller for this endeavour is an Arduino Mega, which can be seen in Fig. 5(a). This particular controller was chosen because it is inexpensive, compatible with several platforms, user-friendly, offers a straightforward programming environment, is based on open-source software, and can be expanded. A variety of electrical devices and sensors may be connected to the Arduino Mega's pins. In addition to its many other capabilities, the Arduino board can take input and transform it into output, receive and send serial data, initiate an interrupt when a low value is detected, and generate 8-bit pulse width modulation (PWM).

2) WI-FI Module ESP8266-The Arduino Mega is connected to the Wi-Fi Module ESP8266, which can be seen in Fig. 5(b). This module has 8 pins and may be found on the board. This module is only compatible with logic levels that are 3.3V

in voltage. For applications involving the Internet of Things, the ESP8266 is the module of choice since it can be purchased for a low cost and has a strong feature set.

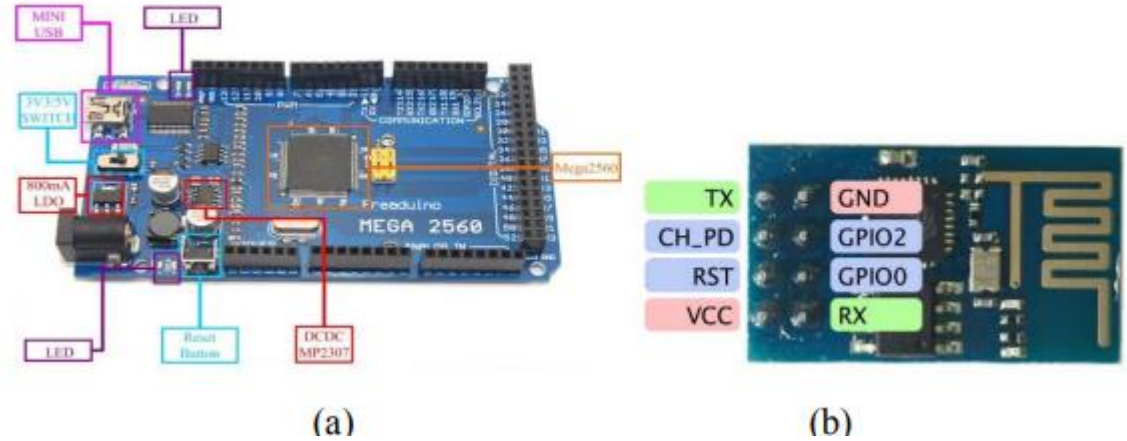

Fig. 5 (a) Arduino Mega 2560 (b) Wi-Fi Module ESP8266

3) Relay Board- The relay board, which is seen in Figure 6, is also employed in this project to link two or more places in response to an input signal. This may be done in a variety of ways. There is a connection between it and the output fan and the light bulbs. Numerous applications make use of relays because of the relative ease of their operation, the length of their lifespans, and the high level of dependability that has been established by these devices. The power is going to be protected, managed, and kept under control for this reason.

Fig. 6 Relay board

In addition to these three fundamental components, the monitoring and administration of a smart home makes use of a wide variety of sensors and devices. Some examples of these are a voltage regulator, temperature sensor, humidity sensor, PIR motion sensor, buzzer, and samples for various domestic appliances such as lighting and fans.

4. Result And Discussion

The purpose of this section is to provide a model that can be used to verify and evaluate the proposed Home Automation System (HAS) implementation. The first results that were acquired for the purpose of this study will serve as the foundation for

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ISSN 2063-5346

additional development and improvement of the system. It is proved that a Wi-Fi-based automation system for smart homes may be developed successfully using Android mobile phones.In order to begin using the system, the first thing that has to be done is to link an Android-based smartphone to a Wi-Fi network that is readily available. After that, the Virtuinoprogram is launched on the mobile device, and the IP address is inputted before the connection is made. The command prompt on a personal computer may be used to acquire the IP address.

Users are now able to manage all of the electrical appliances in their homes and monitor the motion, temperature, and humidity levels around the house once the Virtuinoprogram has been successfully linked to the Wi-Fi network.As can be seen in Figure 7, users of the Virtuino Android app have the ability to manage and monitor electrical appliances such as light bulbs and fans. In addition, the DHT22 sensor is utilized to measure and monitor the temperature and humidity levels within the house directly from the mobile phone that is based on the Android operating system.

In the following phase, this temperature and humidity information may be utilised to fully automate the operation of the air conditioning system and fans for increased comfort and decreased energy use.In addition to this, the motion sensor is able to monitor a particular location for any motion and will sound an alert through a buzzer if it finds any. This feature may be employed at a later time in the security system or to automate the functioning of the lights, which will enhance both security and convenience.The purpose of this part is to demonstrate, via the use of an Android mobile phone and a practical example, how the proposed Wi-Fi-based automation system for smart homes may be implemented practically and how its capability can be utilised. The system successfully controls and monitors electrical appliances as well as environmental factors, therefore setting the groundwork for future developments as well as prospective applications in the fields of home automation and security.

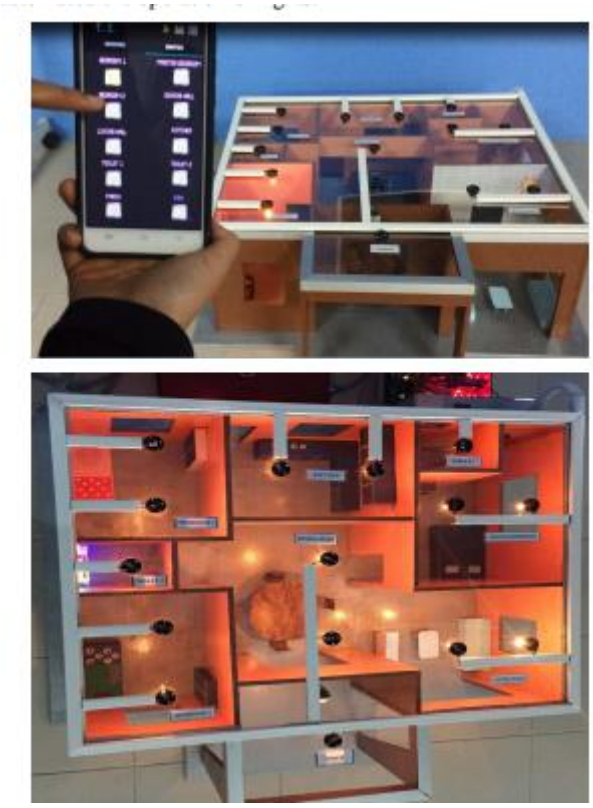

Fig7. House prototype with electrical appliances controlled via Android

As indicated in Figure 8, when we reach the end of this phase of our project, all of the electrical appliances will be able to be controlled by utilising the programme called Virtuino. In addition, an Android-based smart phone may be used to monitor the temperature and humidity in a home, in addition to any motion that may be present.

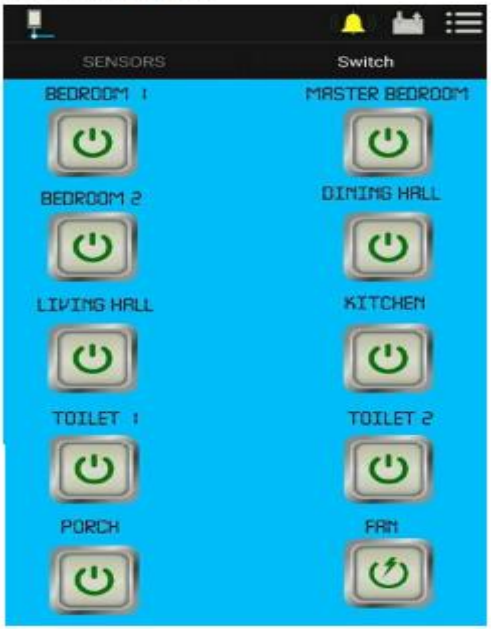

Fig. 7. Developed user interface for switching using Virtuino

Fig. 8. Condition of humidity, temperature and motion at home

5. Conclusion

Using an Arduino and an Android smartphone, this research project was able to effectively develop, build, and create a low-cost Wi-Fi-based Automation System for Smart Home prototype. Wi-Fi connectivity is required for the use of this system, which enables simple and effective management of all electrical appliances within the home, such as light bulbs and ceiling fans.

Inside the home, mobility, humidity, and temperature can all be monitored thanks to the integration of sensors. In addition, the presence of motion triggers the activation of a buzzer, which further increases the level of safety provided by the system.Users will have a better quality of life as a result of the Smart Home Automation System's ability to provide convenience, intelligence, and increased levels of safety. Because users of this smart home system are able to operate electrical appliances at any time without making any kind of physical effort, they are able to cut their monthly power expenditures.The next stage of the research project will involve putting Internet of Things (IoT) principles into practise in order to realise the goal of enabling remote control of the system that has been designed. Because of this, users will be able to operate the system via a webserver even when they are not at their usual location. The research group intends to extend the capabilities of the system by adding additional sensors in order to improve both its safety and security. In addition to that, one of their goals is to offer the opportunity for totally automated control of various household equipment.

In order to accomplish these goals, a gateway will be built and used to link all of the sensors to an Internet of Things platform. In order to solve problems with the wiring and to expand the amount of flexibility available, it is possible that some sensors may be replaced with wireless ones. It is envisioned that the finished product will be a box that is both small and simple to use, and that it will be able to easily integrate into the switching boards of actual houses through the use of a relay board, so assuring safer control of appliances.Overall, the results of this research study illustrate the possibility for a smart home automation system that is both practical and

inexpensive, and that improves the convenience, security, and energy efficiency of the house. In the future, modifications will be made that will further increase the capabilities of the system. These advancements will also pave the way for the system's use in real-world settings, which will benefit homeowners and improve their living experiences.

References

1. Khanpara, P., Lavingia, K., Trivedi, R., Tanwar, S., Verma, A., & Sharma, R. (2023). A context- aware internet of things- driven security scheme for smart homes. *Security and Privacy*, *6*(1), e269.
2. Muneer, S., Alvi, M. B., & Zaheer, M. (2023). An Intelligent Home Energy Management System Using Deep Reinforcement Learning. *International Journal of Advanced Sciences and Computing*, *2*(1), 27-32.
3. Xu, X., Guo, Y., & Guo, Y. (2023). Fog-enabled private blockchain-based identity authentication scheme for smart home. *Computer Communications*, *205*, 58-68.
4. Yudidharma, A., Nathaniel, N., Gimli, T. N., Achmad, S., & Kurniawan, A. (2023). A systematic literature review: Messaging protocols and electronic platforms used in the internet of things for the purpose of building smart homes. *Procedia Computer Science*, *216*, 194-203.
5. Abed, S. E., Jaffal, R., & Mohd, B. J. (2023). A review on blockchain and iot integration from energy, security and hardware perspectives. *Wireless Personal Communications*, *129*(3), 2079-2122.
6. He, S. (2023, February). Research on Intelligent Home System Based on Computer Internet of Things. In *2023 IEEE 2nd International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA)* (pp. 813-817). IEEE.
7. Lopes, S. F., Costa, A. D., & Santos, H. M. D. (2023). Wireless networks and IoT applications. *Mobile Networks and Applications*, 1-3.
8. Sahrab, A. A., &Marhoon, H. M. (2022). Design and Fabrication of a Low-Cost System for Smart Home Applications. *Journal of Robotics and Control (JRC)*, *3*(4), 409-414.
9. Nyangaresi, V. O. (2022). Lightweight anonymous authentication protocol for resource-constrained smart home devices based on elliptic curve cryptography. *Journal of Systems Architecture*, *133*, 102763.
10. Taiwo, O., Ezugwu, A. E., Oyelade, O. N., & Almutairi, M. S. (2022). Enhanced intelligent smart home control and security system based on deep learning model. *Wireless communications and mobile computing*, *2022*, 1-22.
11. Rizou, S., Egyptiadou, E. A., Ishibashi, Y., &Psannis, K. E. (2022). Preserving Minors' Data Protection in IoT-based Smart Homes According to GDPR Considering Cross-Border Issues. *J. Commun.*, *17*(3), 180-187.
12. Ravishankar, V., Vinod, V., Kumar, T., & Bhalla, K. (2022). Sensor integration and facial recognition deployment in a smart home system. In *Proceedings of the 2nd International Conference on Recent Trends in Machine Learning, IoT, Smart Cities and Applications: ICMISC 2021* (pp. 759-771). Springer Singapore.

13. Ahmed, I., Zhang, Y., Jeon, G., Lin, W., Khosravi, M. R., & Qi, L. (2022). A blockchain- and artificial intelligence- enabled smart IoT framework for sustainable city. *International Journal of Intelligent Systems*, *37*(9), 6493-6507.
14. Sepasgozar, S., Karimi, R., Farahzadi, L., Moezzi, F., Shirowzhan, S., M. Ebrahimzadeh, S., ... & Aye, L. (2020). A systematic content review of artificial intelligence and the internet of things applications in smart home. *Applied Sciences*, *10*(9), 3074.
15. Khoa, T. A., Nhu, L. M. B., Son, H. H., Trong, N. M., Phuc, C. H., Phuong, N. T. H., ... & Duc, D. N. M. (2020). Designing efficient smart home management with IoT smart lighting: a case study. *Wireless communications and mobile computing*, *2020*, 1-18.
16. Lin, C., He, D., Kumar, N., Huang, X., Vijayakumar, P., & Choo, K. K. R. (2019). HomeChain: A blockchain-based secure mutual authentication system for smart homes. *IEEE Internet of Things Journal*, *7*(2), 818-829.
17. Jabbar, W. A., Kian, T. K., Ramli, R. M., Zubir, S. N., Zamrizaman, N. S., Balfaqih, M., ... & Alharbi, S. (2019). Design and fabrication of smart home with internet of things enabled automation system. *IEEE access*, *7*, 144059-144074.
18. Talal, M., Zaidan, A. A., Zaidan, B. B., Albahri, A. S., Alamoodi, A. H., Albahri, O. S., ... & Mohammed, K. I. (2019). Smart home-based IoT for real-time and secure remote health monitoring of triage and priority system using body sensors: Multi-driven systematic review. *Journal of medical systems*, *43*, 1-34.