INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD)
© 2026 IJNRD | Volume 11, Issue 6, June 2026 | ISSN: 2456-4184 | IJNRD.ORG

AI-Powered IoT Smart Home System for Enhanced Automation and Energy Efficiency

Mr. Praveen J, A. Muhilarasan, M. Manish

Assistant Professor, Student, Student
Department of Computer Science and Applications,
Jeppiaar College of Arts and Science, Padur -Chennai

Abstract: The development of Smart home has been moving away the simplistic centralized and semi-automated monitoring and control of household systems toward the complex intelligent surroundings of Artificial Intelligence (AI) and the Internet of Things (IoT). IoT is the increase of internet-capable devices, which allows the smooth interaction of all the appliances in the home via standardized protocols and network structures. In this paper, the author discusses how AI solutions, including machine learning, deep learning, natural language processing, and reinforcement learning can be integrated into a smart home system through IoT. The technologies allow devices to follow user behavior, assist in real-time decision-making, and offer individual automation to applications like smart lighting and climate control, as well as security surveillance. Although the fast development has taken place, such issues as complexity in managing systems, data confidentiality, cyber-attacks, and their expensive nature of implementation are still a major concern. IoT architecture is also covered in the paper and important issues are identified with the level of security in servers and devices and solutions to mitigate the challenges. The combination of AI and IoT is considered critical in changing the conventional households into adaptable, efficient and intelligent living spaces.

I. INTRODUCTION

The Internet has highly changed the life of people in this world because it allows them to connect anywhere and at any time. As technology has advanced at a high rate, sensors, processors, transmitters, and receivers are now cheaper and more accessible and can now be added to daily uses. This development has given rise to the tradition internet service expansion to the Internet of Things (IoT), in which physical objects and devices are networked together based on standard network architecture and communication protocols.

IoT describes a network where physical devices such as home appliances, vehicles, and devices are joined to the internet and can communicate among themselves (things-to-things) and to humans too (things-to-human). These intelligent objects are able to work independently, self-configure and communicate data without human intervention. Consequently, IoT ceases to be a technological fanciful notion but a fast-evolving technology that affects different spheres, such as smart homes.

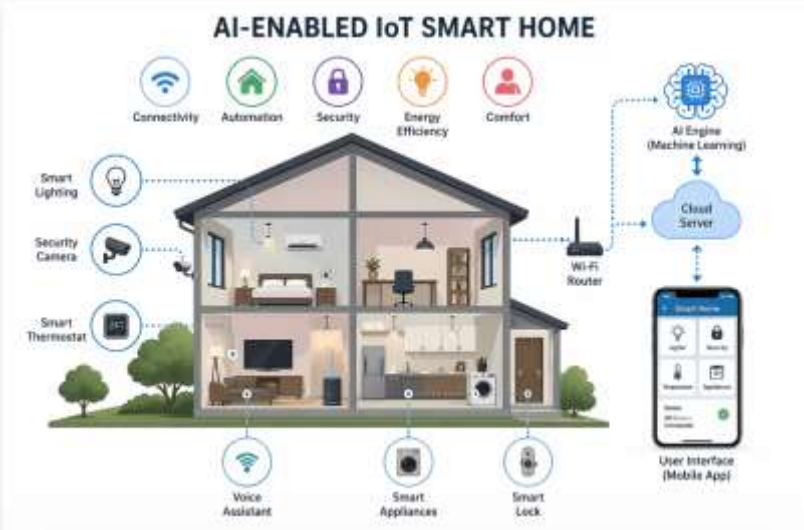

Figure 1.1: AI - Enabled IoT Smart Home

A smart home is a residential environment where household devices and appliances are interconnected and can be monitored, controlled, and automated remotely via the internet. These systems typically consist of sensors, switch modules, communication devices, and a central controller that manages data exchange between devices and servers. Technologies such as RF transceivers, microcontrollers, and communication modules (e.g., Zigbee or GPRS) enable seamless interaction among devices. Smart home systems allow users to control appliances such as lighting, fans, and security systems efficiently through predefined architectures and protocols.

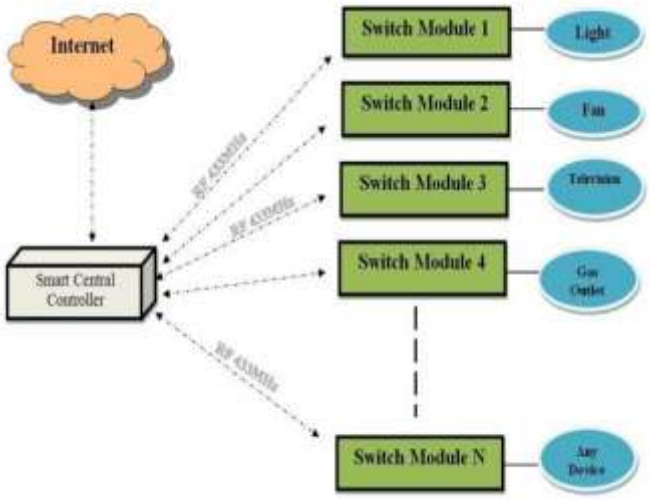

Figure 1.2: Smart Central Controller

The integration of Artificial Intelligence (AI) with IoT further enhances smart home capabilities by enabling intelligent decision-making and adaptive behavior. AI techniques such as machine learning, deep learning, natural language processing, and reinforcement learning allow systems to learn user preferences, optimize energy usage, and improve security through real-time monitoring and automation.

Despite these advancements, several challenges remain, including system complexity, data privacy concerns, cybersecurity risks, and high implementation costs. Therefore, ensuring secure communication and efficient management of interconnected devices is essential for the reliable operation of smart home systems. This paper aims to examine AI approaches in IoT-based smart homes, analyze their applications, and discuss challenges along with possible solutions to improve system performance, security, and scalability.

II. LITERATURE REVIEW

Luigi Atzori et al. (2010) presented the fundamental concept of the Internet of Things (IoT), explaining how interconnected devices communicate through standardized protocols and network architectures. Their work provided a comprehensive overview of IoT vision, applications, and key enabling technologies, laying a strong foundation for the development of smart home systems with a focus on scalability, interoperability, and seamless connectivity.

Jayavardhana Gubbi et al. (2013) discussed the application of IoT in smart environments, particularly in smart homes. They emphasized the integration of cloud computing and data analytics for processing and managing large volumes of data generated by connected devices. Their study highlighted how IoT systems can enable real-time monitoring, efficient resource management, and improved user experience.

Dinh C. Nguyen et al. (2019) explored the integration of Artificial Intelligence (AI) with IoT systems, often referred to as AIoT. Their research demonstrated how machine learning and deep learning techniques enhance automation, support predictive analysis, and improve energy efficiency in smart homes. They also discussed the role of AI in enabling intelligent decision-making and adaptive system behavior.

Sherali Zeadally et al. (2020) focused on the challenges associated with IoT-based systems, particularly in terms of data privacy, security vulnerabilities, and system complexity. Their study emphasized the importance of implementing secure communication protocols, data protection mechanisms, and robust architectures to ensure the reliability and safety of smart home environments.

III. EXISTING SYSTEM

Existing IoT-based smart home systems are designed using layered architectures and various hardware and communication technologies. Kang Bing et al. proposed a three-layer architecture consisting of sensing, network, and application layers. The sensing layer collects data from home appliances using sensors and microcontrollers, while the network layer transmits data through communication protocols such as Zigbee. The application layer processes the data and provides user-level services.

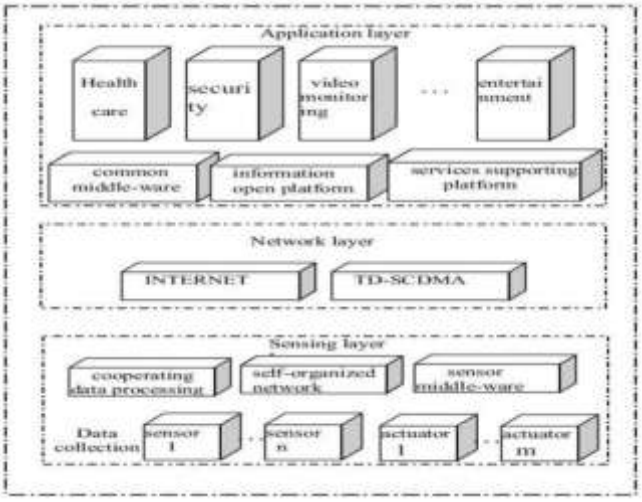

Figure 3.1: Layer involved in IoT network

Qingping Chi et al. developed a reconfigurable smart sensor interface using CPLD/FPGA for wireless sensor networks. Compared to microcontrollers, these devices support parallel data processing and improve real-time system performance, making them suitable for complex smart environments.

Ming Wang et al. and Sarita Agrawal et al. introduced smart home control systems based on RF communication (433 MHz), where devices are connected through switch modules and controlled via a central controller. RFID technology is also used to assign unique identities to devices, enhancing system security and device management.

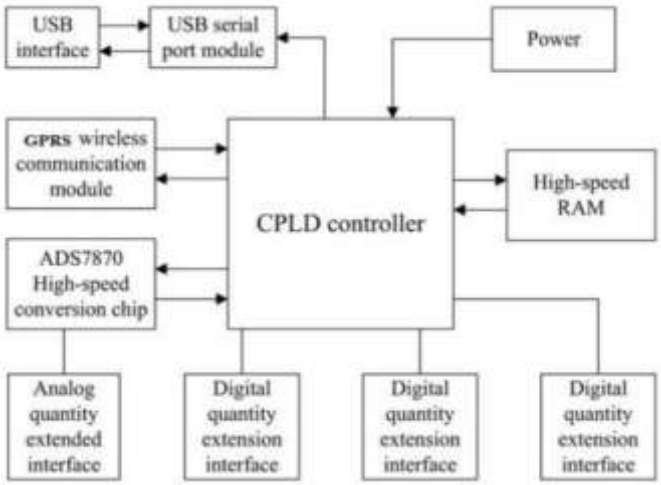

Figure 3.2: CPLD Controller

Several researchers have addressed communication and security challenges. Tongtong Li et al. proposed a Secure Access Gateway (SAG) for safe interaction between users and devices, while Yue Li introduced a lightweight key establishment protocol for secure communication in smart home networks. Additionally, Vittorio Miori et al. proposed DomoNet, a software framework to improve interoperability between different smart home devices using IPv6.Although these systems provide automation and connectivity, they face limitations such as lack of interoperability, security vulnerabilities, and high system complexity.

IV. PROPOSED SYSTEM

The proposed system is an **AI-enabled IoT-based smart home system** designed to provide intelligent automation, enhanced security, and efficient energy management. Unlike existing systems that rely mainly on predefined rules, the proposed system integrates Artificial Intelligence (AI) to enable adaptive and real-time decision-making based on user behavior and environmental conditions.

The system consists of three main components: **sensing layer, processing layer, and application layer**. The sensing layer includes various sensors such as temperature, humidity, motion, and light sensors, which continuously collect real-time data from the home environment. This data is transmitted to the processing layer through communication technologies such as Wi-Fi or Zigbee.

The processing layer acts as the core of the system and includes a microcontroller or embedded processor integrated with AI models. Machine learning algorithms analyze the collected data to identify patterns and predict user preferences. Based on this analysis, the system can automatically control household devices such as lights, fans, air conditioners, and security systems.

The application layer provides a user interface through mobile applications or web platforms, allowing users to monitor and control devices remotely. It also displays real-time data and system alerts for better decision-making.

To enhance security, the proposed system incorporates authentication mechanisms and encrypted communication protocols to protect user data and prevent unauthorized access. Additionally, energy optimization techniques are applied to reduce power consumption by intelligently managing device usage.

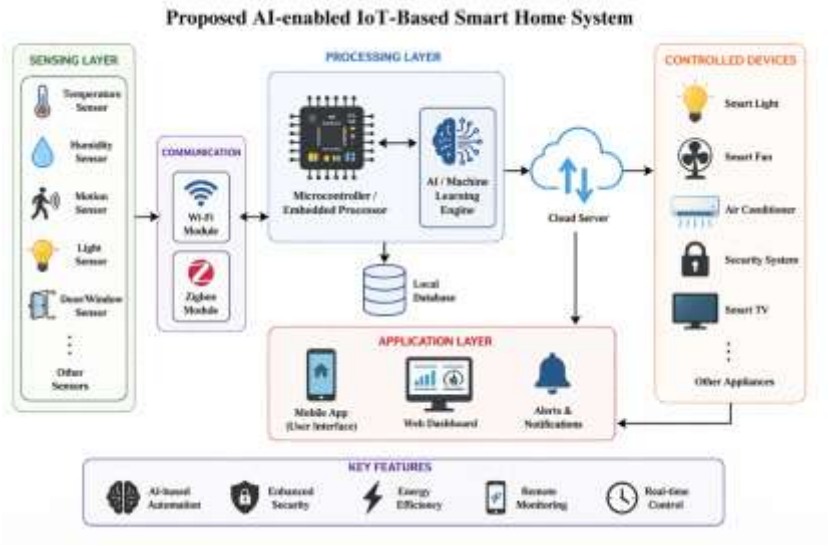

Figure 4.1: Proposed system

Overall, the proposed system improves upon existing models by integrating AI for smart decision-making, ensuring better automation, security, and energy efficiency in smart home environments.

V. RESULT AND DISCUSSION

The proposed AI-based IoT smart home system was evaluated in terms of automation, energy efficiency, and security. The system demonstrated effective real-time monitoring and control of household devices using sensor data and intelligent decision-making. Devices such as lights and appliances responded automatically to user behavior and environmental conditions, confirming the efficiency of AI techniques.

Machine learning algorithms enabled the system to learn user preferences and optimize device usage, resulting in reduced energy consumption. Reliable communication was achieved using technologies such as Wi-Fi and Zigbee, allowing remote access through a mobile application.

The system also enhanced security by generating alerts for unusual activities. However, challenges such as network dependency, latency, and data privacy concerns were observed. Overall, the system proved to be efficient, reliable, and capable of intelligent automation.

VI. CONCLUSION

This paper presented an AI-based IoT smart home system that enhances automation, security, and energy efficiency. The integration of Artificial Intelligence enables intelligent decision-making by analyzing user behavior and environmental conditions, while IoT ensures seamless communication between interconnected devices. The system effectively monitors and controls household appliances in real time, improving user convenience, safety, and overall quality of life.

Despite these advantages, certain challenges such as data privacy concerns, cybersecurity risks, and system complexity need to be addressed for large-scale implementation. Nevertheless, the proposed system demonstrates strong potential in transforming traditional homes into smart and adaptive environments. Overall, the combination of AI and IoT plays a significant role in the development of efficient, secure, and intelligent smart home systems.

References

[1] L. Atzori, A. Iera, and G. Morabito, "The Internet of Things: A Survey," *Computer Networks*, vol. 54, no. 15, pp. 2787–2805, 2010.

[2] J. Gubbi, R. Buyya, S. Marusic, and M. Palaniswami, "Internet of Things (IoT): A Vision, Architectural Elements, and Future Directions," *Future Generation Computer Systems*, vol. 29, no. 7, pp. 1645–1660, 2013.

[3] D. C. Nguyen, P. N. Pathirana, M. Ding, and A. Seneviratne, "AIoT: Artificial Intelligence of Things: A Survey," *Future Generation Computer Systems*, vol. 97, pp. 562–578, 2019.

[4] S. Zeadally, A. K. Das, N. Sklavos, and K. K. R. Choo, "Security and Privacy in Smart Homes: Issues, Challenges, and Solutions," *IEEE Communications Magazine*, vol. 58, no. 6, pp. 86–92, 2020.

[5] Qingping Chi, Hairong Yan, Chuan Zhang, Zhibo Pang, and Li Da Xu, "A Reconfigurable Smart Sensor Interface for Industrial WSN in IoT Environment", IEEE Transactions on Industrial Informatics, vol. 10, no. 2, May 2014

[6] Arjun P. Athreya, and Patrick Tague, "Network SelfOrganization in the Internet of Things", IEEE International Workshop of Internet-of-Things Networking and Control (IoT-NC), 2013, pp. 25-33

[7] Moataz Soliman, Tobi Abiodun, Tarek Hamouda, Jiehan Zhou, and Chung-Horng Lung, "Smart Home: Integrating Internet of Things with Web Services and Cloud Computing", IEEE International Conference on Cloud Computing Technology and Science, 2013, pp. 317-320

[8] Kang Bing, Liu Fu, Yun Zhuo, and Liang Yanlei, "Design of an Internet of Things-based Smart Home System" July 2011, pp. 921-924

[9] Vladimir Gurevich, "Electric Relays Principles and Applications", Taylor and Francis Group, 2006, pp. 1- 52

[10] Yu-Qing Bao and Yang Li, "FPGA-Based Design of Grid Friendly Appliance Controller", IEEE Transactions On Smart Grid, Vol. 5, No. 2, March 2014, pp. 924-931

[11] M. Wang, G. Wang, and J. Zhang, "Design of Smart Home Control System Based on ZigBee Wireless Sensor Network," *International Conference on Intelligent Systems Design and Engineering Applications*, 2010.