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Development and implementation of a smart home automation system in the context of the Ukrainian housing sector: Challenges and prospects

Pavlo Kuznetsov*

Master

Pryazovskyi State Technical University

49000, 29 Gogol Str., Dnipro, Ukraine

<https://orcid.org/0009-0001-0762-9958>

Abstract. Due to the rapid development of technology and the growing interest in the concept of “smart home”, the relevance of the study is to identify obstacles and opportunities, contributing to the effective implementation of these technologies in modern life. The purpose of this study is to analyse the modern state and determine the possibilities of developing and implementing smart home automation systems in the Ukrainian residential sector to increase the level of comfort, safety, and energy efficiency. The methods used include the analytical method, classification, functional method, statistical method, synthesis, etc. The results of the study reveal the profound impact of technology on the efficiency and security of a smart home. The modern state of smart home automation systems in the Ukrainian residential sector was analysed. Modern cybersecurity methods for protecting against potential threats were considered. Electronic keys, including Face Identification, fingerprint and voice recognition technologies, are being implemented to provide access and increase security in the smart home. The study reveals various methods that are used in different countries to implement smart homes, presenting various examples of development and features of their implementation. As a result, key technical and financial challenges are identified that call into question the effectiveness of implementing such systems. In addition, the possibilities of optimising these systems were considered based on market features and infrastructure constraints. According to the analysis, specific recommendations were developed for creating affordable and effective solutions for Ukrainian consumers. Based on these recommendations, it can be concluded that, despite the existing difficulties, the introduction of smart home systems in Ukraine has potential and prospects. However, to achieve full success, it is important to overcome technological challenges and consider the financial capabilities of the population. The study made a significant contribution to understanding the factors influencing the successful implementation of modern technologies in the residential sector of Ukraine, contributing to the practical development of science and providing concrete conclusions for the possibilities of implementing smart home automation systems

Keywords: technologies; energy efficiency; technical methods; recommendations; infrastructure constraints

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INTRODUCTION

The growing interest in the smart home concept is driven by the desire to improve comfort, safety, and energy efficiency in residential areas. Smart home automation systems, due to their capabilities, provide automated control of various devices and systems in the home, which leads to numerous advantages. They contribute to increased comfort by automatically performing routine

tasks such as controlling lighting, adjusting temperature, and opening doors. This not only frees up the time and effort of residents, but also makes their lives convenient. An important aspect is to increase security, as automation systems can control access to the home, detect and prevent hazards, and provide remote home management. This is important to protect against burglary,

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*Corresponding author



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fire, and other potential hazards. In addition, automation systems help to improve energy efficiency by optimising energy use in the home. This reduces energy supply costs and minimises the negative impact on the environment.

The research focuses on identifying and developing optimal strategies for implementing smart home automation systems in the Ukrainian residential sector. This includes a thorough analysis of the technical and financial challenges that arise when implementing modern technologies, identifying market constraints, and infrastructure challenges. Confronting these aspects is a key issue, as it determines the success or failure of implementing smart technologies in the housing sector of Ukraine. Insufficient standardisation, financial constraints, and infrastructure variability are becoming important aspects that need to be studied and addressed to ensure the effective implementation of smart systems in the home environment.

The study by K. Halahura *et al.* (2022) highlighted the rapid development of technology and increased interest in the smart home concept, which determines the relevance of the study. The study did not address specific technical aspects of implementing smart systems in the residential sector. E. Khomenko and O. Lemeshchuk (2023) identified key technical and financial challenges that arise when implementing smart home automation systems in the Ukrainian residential sector. The study does not focus on the interaction between different manufacturers of smart systems and the possibility of standardisation. N.G. Aksak *et al.* (2024) noted the importance of considering the possibilities of optimising systems considering market characteristics and infrastructure constraints in the context of implementing a smart home. The study did not address the impact of financial constraints on the decision to implement smart home systems. A.V. Kharytonovych and M.O. Nazarenko (2023) noted that identifying and solving problems of technical and financial challenges is a critical stage for the successful implementation of automation systems. The researchers did not analyse the possibilities of optimising automation systems with regard to infrastructure constraints.

Research conducted by L.M. Vilinska *et al.* (2023) highlighted the importance of energy efficiency and the possibility of reducing resource consumption when implementing smart systems in residential areas. The paper did not address aspects of efficiency and reduced resource consumption in the context of smart residential systems. The study by Yu. Hasiuk *et al.* (2023) raised the issue of standardisation in the context of implementing smart home systems, which determines consistency and compatibility between different manufacturers and platforms. The possibility of developing affordable solutions for Ukrainian consumers was not considered by the researchers. M.I. Hrytsaienko and H.I. Hrytsaienko (2021) analysed the concept of a "smart home", established the composition and interrelation of the main components of this hierarchical system, and

based on a survey of residents of two-room apartments with underfloor heating, a conclusion was made about the feasibility of investing in its energy efficiency. The study did not consider the possibility of using the integration of electronic keys and security systems based on Face ID (Identification), fingerprint and voice recognition technologies to increase the level of protection and comfort of smart home users.

As part of a study conducted by Ya. Kovivchak *et al.* (2021), an information system was developed aimed at optimising and controlling electricity consumption in a smart home. The study did not examine the impact of using alternative energy sources, such as solar panels or wind turbines, on power management in a smart home. I.M. Lukyanovets and N.K. Lysa (2022) stressed the importance of paying attention to the risks and security of a smart home, which include the collection and processing of personal data, the possibility of confidential information leakage, cyber-attacks, and unforeseen situations in the operation of systems, which highlights the need for security measures to ensure the reliability and protection of privacy in a smart home. The researchers did not address the possibility of implementing data encryption or blockchain technologies to provide an additional layer of security and privacy protection in smart homes.

The purpose of this study was to explore how smart home automation systems can be implemented in Ukraine to make housing more comfortable, safe, and energy efficient.

MATERIALS AND METHODS

The analytical method helped to consider and investigate key aspects of the functioning of smart home automation systems. Using this method, it was possible to analyse the various technical and operational characteristics of these systems, and determine their effectiveness and possible areas of improvement. The analysis of the data obtained provided a sound understanding of the advantages and limitations of using smart technologies in the housing sector.

Using the functional method, the functionality of smart home automation systems was identified and studied in detail. This approach determined how systems interact with different devices and equipment, and how they affect different aspects of the household environment. The study of functional characteristics revealed the possibilities of controlling lighting, heating and air conditioning systems, safety systems, and other aspects of living space. Considering such functionality, recommendations were developed for the optimal use of automation systems, contributing to maximum comfort and safety for residents.

The deduction helped in determining the logical conclusions and patterns underlying the implementation of smart home automation systems. Investigating the general principles and principles on which these systems work, key aspects that determine their effectiveness and capabilities were identified. The deduction

has contributed to the formulation of predictions and strategies for the future improvement of smart housing. Exploring the limitations and opportunities, the study identified ways to optimise and develop new functionality that will contribute to further growth of comfort and safety in modern residential premises.

The synthesis combined various elements and components to create complete and optimal smart home automation systems. This approach allowed integrating different technologies, ensuring their interaction to achieve maximum functionality. By exploring various aspects from basic technical characteristics to user interfaces, the synthesis has made it possible to create systems that effectively meet the needs and expectations of users. Considering the principles of design and interaction of components, solutions have been synthesised that improve the comfort, safety and energy efficiency of residential premises.

The classification method helped to systematise and categorise the diversity of smart home automation systems according to their technical characteristics and functionality. The operational inspection identified groups of systems by their purpose, scope of functions, and level of automation. This method allowed identifying key features and distinguishing between different types of systems depending on their application. The classification was useful for understanding and determining the best options for choosing automation systems based on the individual needs and preferences of users. Using the induction method, various scenarios for using smart home automation systems in the Ukrainian residential sector were studied. This method analysed previous cases of successful implementation, identifying key aspects that lead to positive results. The induction also identified important factors for successful implementation, such as providing the appropriate technical infrastructure, user training, and developing data security systems. Consideration of these factors when planning and implementing automation systems is important to ensure stability and long-term efficiency.

RESULTS

The development and implementation of smart home automation systems in the Ukrainian residential sector can be an effective solution for improving comfort, safety, and energy efficiency. The Internet of Things (IoT) is a network of interconnected devices that can transmit and process data. These devices are equipped with software and built-in sensors that allow them to exchange information on a global or local network. Using IoT systems can simplify everyday tasks, providing people with a more dynamic and comfortable lifestyle. For example, in smart homes, IoT devices can automatically activate lighting when a person enters a room or adjust the temperature according to the specified parameters. In addition, home IoT devices can interact with each other and provide various services to users. For example, a smart assistant can play music from the owner's library

or perform certain tasks on other IoT devices according to saved daily tasks. Thus, IoT devices can make a person's life easier by performing various tasks without direct intervention or at the user's command.

Smart technologies in modern homes are becoming increasingly popular, attracting the attention of both individual owners and government agencies around the world. Some countries are already successfully implementing smart home systems that promote comfort, safety and energy efficiency. In the United States, voice assistants are popular, allowing users to control various aspects of the home using voice commands. Technologies such as Amazon Alexa, Google Assistant, and Apple HomeKit are becoming an integral part of modern homes, providing convenient management of various systems. Sweden is actively using energy-efficient solutions aimed at optimising energy consumption and reducing emissions. Much attention is paid to the use of solar panels, renewable energy systems, and intelligent power consumption management systems. In the Netherlands, homes are equipped with integrated smart home systems for easy management of all aspects of life. This includes automated control of lighting, heating, air conditioning and safety systems, making their homes comfortable and efficient. In South Korea, smart technologies are being implemented in new housing construction to ensure optimal comfort and safety for residents. Innovative lighting, heating, and safety control systems are becoming the standard in new buildings. China, as a leader in smart technologies, actively uses systems to manage energy consumption and infrastructure in cities. Major cities such as Shanghai and Beijing illustrate the diversity of innovative approaches in the world of smart construction, where the use of artificial intelligence and smart city systems helps improve the comfort and quality of life of residents.

Smart technologies in construction not only make life easier, but also become a key factor in ensuring safety, energy efficiency and convenience for residents around the world. These technologies continue to evolve and be implemented, creating new opportunities to improve the quality of life and save resources. The world is becoming increasingly dependent on technology, and in this context, the concept of a "smart home" is becoming not only a novelty, but also a necessity. The smart home system embodies the idea of integrating various devices and sensors into one complete system that provides convenience, comfort, and safety for residents (Fig. 1). This system works by collecting data from various sensors and devices, analysing them through special software, and executing appropriate commands to control various home systems. A central part of a smart home system is its ability to collect and analyse data. Light, motion, temperature, humidity, and other sensors provide a constant flow of information about the state of the house and its surroundings. This data is then transmitted to a central controller, where it is analysed and used for decision-making. Light sensors

detect the level of illumination in different areas of the house and transmit this information to the central controller. Based on this information, the system can automatically turn on or off indoor lights, adjust the brightness of the light according to the time of day, or act according to certain specified scenarios. A smart home

system can manage other aspects of home life, such as heating, ventilation, air conditioning, water management, and other systems. This provides comfortable living conditions for the residents of the house and reduces energy consumption by optimising the operation of heating and air conditioning systems.

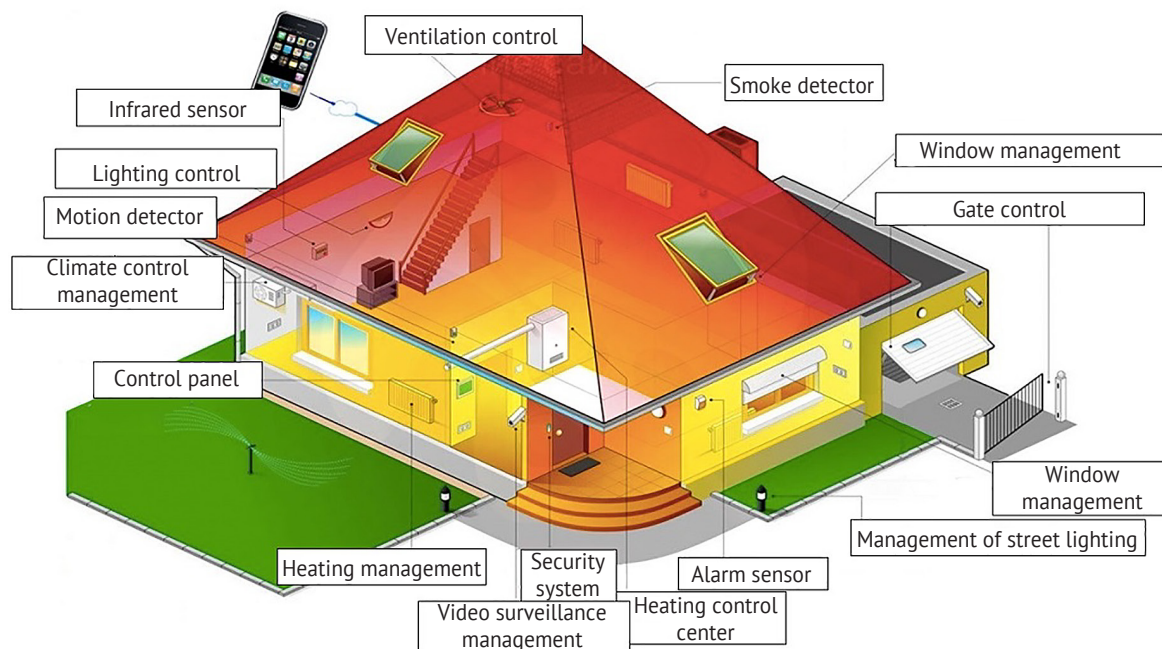


Figure 1. Smart home system operation diagram

Source: compiled by the author

Figure 2 shows signal management tools within the network, such as a smartphone, router, and cloud server. In this topology, the smartphone is used to manage IoT devices and make changes to their settings. The router is responsible for automating the process of managing devices on the local network, ensuring

effective coordination of their work. The cloud server is used for remote management of device settings, providing convenient and accessible management even from a distance. This configuration allows effectively managing IoT devices in a smart home, providing convenience and flexibility in their use.

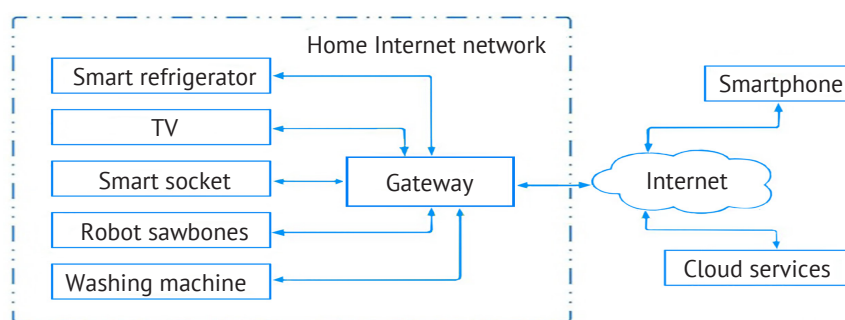


Figure 2. Network used in the smart home ecosystem for IoT devices

Source: compiled by the author

Smart home automation systems can be divided according to several key characteristics and functionality. In particular, they differ in control method, power consumption, security systems, device integration, automation of routine tasks, and scalability. As for the control method, the systems can use voice or mobile control.

The main areas of energy consumption include energy efficiency and the use of renewable energy sources. Security systems may include video surveillance and access control. In terms of device integration, IoT support and integration with entertainment electronics (TVs, music centres, etc.) are important. Automating routine

tasks may include controlling lighting and climate control. Scalability systems can be single-level or integrated, covering all aspects of the home. This systematisation helps to understand the diversity of systems and determine their relevance to the specific needs and ideas of users. Software for smart home systems can have a variety of forms and interfaces designed for different target audiences and user needs. The most common options include web applications, mobile applications, and specialised platforms.

Web applications are one of the available smart home management software options. They usually work via a web browser and provide users with the ability to remotely manage various aspects of their home environment. This is a convenient solution for those who want to have access to the home management system from any device with an internet connection. Mobile applications have become an integral part of modern smart home systems. They provide users with convenience and mobility, allowing them to control lighting, heating, security, and other functions via their smartphone or tablet. Mobile applications often also include monitoring and notification features, making them an essential tool for keeping home safe and comfortable. Specialised platforms are more advanced and integrated solutions for smart home management. They often combine various functions, including automation, monitoring, and management, and can also be integrated with other systems, such as security systems or energy management systems. In modern smart homes, sensors play a key role in collecting a variety of information about the environment, including temperature, humidity, lighting, and movement. This data can be used to automate various home systems, such as heating, air conditioning, lighting, and security systems.

Controllers in smart homes are responsible for controlling various devices and systems based on the received data. They can make decisions automatically or using user-developed programmes. For example, the controller can automatically turn off the heating when sensors detect that the room has become warm enough. Other IoT devices that are connected to a smart home can include various household devices, such as refrigerators, washing machines, coffee makers, and many others. These devices can be controlled remotely via mobile applications or voice assistants, giving users more convenience and control over their home. One of the most important aspects of IoT systems in smart homes is their ability to interact and integrate with other systems. For example, motion sensors can turn on the lighting system, or the heating system can turn off when the windows are open. This makes smart homes not only convenient, but also more efficient in using energy and resources. Conventional door keys are gradually being replaced by electronic identification systems that offer a higher level of security and convenience. The use of electronic keys such as fingerprints, Face ID, or voice recognition is becoming the standard

for providing security and access to homes in modern smart systems.

One of the most common methods of electronic identification in smart homes is the use of fingerprints. This method is based on the unique biometric characteristics of each person, which makes it reliable and almost unforgeable. In addition, the use of fingerprints allows quickly and conveniently opening the door without having to carry a physical key. Face ID, based on facial recognition, is another innovative method of electronic identification. This technology is used in smartphones and other devices to unlock by scanning the user's face. In smart homes, Face ID systems can be integrated with smart doors or access control systems, allowing owners to access their home with just their face. Voice recognition is another advanced electronic identification method that finds its application in smart homes. This technology allows users to authorise their access to the home using voice commands or simply by recognising their voice. It is especially convenient for those who have a limited ability to move or have various physical limitations.

Cybersecurity is becoming an important aspect for ensuring data security and privacy in smart homes. Given the constant growth in the number of connected devices and the relationship between them, protection against unauthorised access and abuse by intruders is becoming an important task for smart home owners. One of the key aspects of cybersecurity in smart homes is network protection. It is important to have a strong and secure network protocol to prevent unauthorised access to home management systems. Setting passwords, using Secure Wi-Fi (Wireless Fidelity) networks, and regularly updating software are just a few of the ways to protect the network from potential cyberattacks. Data encryption is another important aspect of cybersecurity in smart homes. All data transmitted between devices on the network must be encrypted to prevent interception and abuse. The use of modern encryption methods, such as Secure Sockets Layer (SSL) or Advanced Encryption Standard (AES), can significantly increase the level of data protection in smart homes. Authentication also plays a key role in ensuring cybersecurity in smart homes. To access home management systems, users must go through an authentication procedure, such as entering a password or using biometric identification methods. This ensures that only authorised users have access to smart home functions.

Financial restrictions are related to the cost of high-tech automation systems. Most innovative solutions in this area are characterised by high purchase and installation costs. For many Ukrainians who have limited financial resources, this becomes the main barrier to access to the benefits of smart housing. The cost of technological solutions, such as intelligent lighting, video surveillance systems, or automated heating systems, can be a big obstacle to their implementation. Overcoming this problem will require developing new

pricing strategies and financial support. Citizens should have access to special credit programmes or subsidies that will help reduce the financial barrier and promote greater adoption of smart technologies in households. In addition, it is necessary to actively work on improving the financial literacy of citizens. Providing information about the efficiency and long-term benefits of using high-tech systems can help to understand not only the cost of installation, but also reduce utility costs in the future (Li *et al.*, 2021). Initiatives to improve financial literacy may include information campaigns, trainings, and seminars for the public. In addressing this issue, it is also important to involve governmental and non-governmental organisations, develop social support programmes and promote the development of the market for high-tech systems at affordable prices. Providing access to modern technologies for all segments of the population can improve the quality of life and make society more efficient and environmentally conscious.

Smart homes, with their innovative technologies, define a new level of comfort and safety in modern housing construction. However, in Ukraine and other countries where the technical infrastructure may remain insufficient, ensuring the full operation of smart home systems can be a serious challenge. One of the key aspects that determine the functionality of smart home systems is access to a fast and stable Internet. In some regions of Ukraine, there may be limited availability of high-speed Internet, which limits the possibility of implementing modern technologies in households. The lack of a reliable internet connection can lead to a gap in the operation of automation systems, reduce their efficiency, and limit interaction between different devices (Aliero *et al.*, 2021). To solve this problem, it is necessary to focus on the development of technical infrastructure, in particular the Internet. Public and private initiatives should be aimed at expanding access to high-speed internet in all regions of the country. This may include building new networks, improving existing infrastructures, and using the latest technologies to improve data transmission efficiency. In addition, it is important to encourage initiatives and partnerships between government agencies, Internet service providers, and smart home technology developers. Support and cooperation in these areas can help ensure not only a fast and stable Internet connection, but also raise public awareness about the benefits of using smart technologies. An additional step may be the introduction of IoT technologies to create a network that works efficiently at low Internet speeds and ensures stable data exchange between devices. This approach can be particularly useful for regions with limited access to high-speed Internet.

Solving the problem of insufficient technical infrastructure for smart home systems in Ukraine requires a comprehensive approach that combines technical, social, and economic aspects. Only through joint efforts can conditions be created for the full implementation and development of smart living in Ukrainian house-

holds. One of the main security threats in smart home systems is the potential vulnerability to cyber-attacks. Increasing the number of connected devices on the same system creates many points for possible attacks. Such attacks can target leaks of sensitive personal data, such as lighting schedules, video surveillance, or even information about residents' habits. To ensure the security of such systems, it is important to develop high-tech encryption tools and security mechanisms that make it difficult for unauthorised persons to access. Another important aspect is control over data storage and processing. Smart home systems usually collect a large amount of information about users' lifestyle. Ensuring the confidentiality and security of this data requires effective storage rules, strict access policies, and the use of advanced encryption technologies (Abdi *et al.*, 2021). In addition, users should have full control over what information is stored and how it is used, ensuring transparency and trust.

Preventing unfair actions of internal or external threats is also important for ensuring data security in smart home systems. Developers and manufacturers should constantly update their software and hardware, and provide users with automatic update capabilities to fix detected vulnerabilities. Regular security checks, audits, and system monitoring can help to identify and fix potential problems in a timely manner. To increase user confidence in smart home systems, it is important to perform effective educational work. Explaining and providing information about the security measures taken in systems can help build a conscious attitude to technologies and confidence in their security. Standardisation is defined as a key factor in the successful implementation and adoption of smart home technologies. One of the main advantages of setting standards in the smart home industry is to ensure compatibility between devices and systems from different manufacturers (Van de Kaa *et al.*, 2021). The lack of a single standard platform can lead to the fact that devices from different manufacturers may not interact effectively or may not be compatible at all. This becomes a serious limitation for consumers who may want to combine devices from different manufacturers into a single integrated system. Standardisation also helps to improve the level of security. If all manufacturers adhere to the same standards for data protection and device security, this allows creating a single reliable framework for protecting against cyber threats and abuse. However, it is important to note that the effectiveness of standardisation depends on active participation and cooperation between manufacturers, industry organisations, technical experts, and government agencies. The process of developing and agreeing on standards should be open and transparent to consider the diverse needs of the industry and protect the interests of end users.

Addressing the lack of standards also opens up opportunities for innovative solutions and industry development. The introduction of a single standard platform

can make the smart home market more attractive to manufacturers and consumers, driving competition and innovation. The use of smart home systems can significantly facilitate the daily life of residents, starting with lighting automation. Residents can control the light in the house, adjust its brightness and colour scheme using a mobile phone or voice commands. This not only creates an atmosphere that matches the mood of residents, but also effectively saves electricity. Heating and air conditioning are also becoming part of an integrated system that can be controlled remotely (Yang *et al.*, 2021). Residents can adjust the temperature in the house using their smartphones or tablets, which ensures optimal comfort even before returning home. One of the important advantages is also the ability to control various household devices through a centralised smart home system. From kitchen appliances to security systems, residents can effectively interact with various aspects of their home environment. Smart home systems can also adapt to the rhythm of life of residents. They can learn habits and adapt home settings for optimal comfort. For example, the system can automatically adjust the lighting and temperature, providing a pleasant environment during dinner or evening relaxation.

Smart home systems allow to effectively control lighting. Automatic switching off of light in rooms where its use is not required is just one example of optimising energy consumption. Motion sensors and presence recognition systems can adjust the light intensity depending on the activity of residents, ensuring efficient use of energy without excessive lighting. Managing electrical appliances and household appliances through a centralised system also contributes to the rational use of energy (Mahapatra & Nayyar, 2022). Remote shutdown or switching to power-saving mode allows saving energy when the devices are not in use. It is also important to note that saving energy through smart home systems not only reduces utility bills, but also helps reduce carbon dioxide and other harmful substances. Thus, these technologies make an important contribution to environmental sustainability. Smart home systems are an important tool for increasing the level of protection of residents and their property, providing innovative approaches to solving security problems. One of the key advantages is the ability to install monitoring and video surveillance systems in different areas of the house. These systems allow residents to monitor events in the house or its surrounding area in real time using mobile devices. Such access provides a sense of security and control, even when residents are not at home. Smart home systems can integrate motion sensors and door sensors that detect unwanted activity or intrusion (Taiwo & Ezugwu, 2021). If suspicious events are detected, the system can send instant notifications to residents' mobile devices or automatically activate security systems such as alarms or security calls.

Security systems in a smart home can also be linked to other functions, such as access control. The use of

electronic keys or face recognition systems allows access only to authorised persons, increasing the overall level of protection. Increased security is also made possible by remote system management. Residents can remotely lock doors, turn on or off alarms, and monitor other aspects of security, even when they are away from home. The growing popularity and integration of smart technologies in homes open up new prospects for increasing the value of real estate. This trend not only reflects modern technological trends, but also has a potentially significant impact on the real estate market. One of the key benefits is to improve the comfort and functionality of homes. Smart systems allow residents to remotely control lighting, heating, air conditioning, security systems, and many other aspects, making their lives more comfortable and efficient. Potential buyers may be willing to pay for this level of convenience and automation. Increased security can also have a positive impact on the value of real estate. Homes with installed monitoring and video surveillance systems can be more profitable for buyers who value their security and privacy highly (Vetrivel *et al.*, 2023). This can lead to an increase in demand for such properties and, accordingly, to an increase in their cost. Energy efficiency measures can also be a significant factor in increasing the value of real estate. Consumers are increasingly aware of the importance of energy conservation, and having systems that aim to optimise energy use in the home can make real estate more attractive. In addition, the smart housing market is constantly evolving, and qualified buyers may be interested in homes equipped with advanced technologies. This can contribute to an increase in demand for such properties and increase their value.

DISCUSSION

Smart home automation systems in the Ukrainian residential sector represent an innovative industry that promises to transform the way residents can interact with their environment in everyday life. The growing interest in these technologies in Ukraine is conditioned by the need to improve comfort, energy efficiency and safety in residential premises. In the course of reviewing the study, a general structure of the home network was created, considering the elements of a smart home. This generalised model identified the key components that make up a smart home system, helping to understand their relationships and their impact on the overall network architecture. Increased comfort is an important factor, as automation systems can perform routine tasks such as controlling lighting, temperature, and safety systems. This makes everyday life not only more convenient, but also more efficient.

Energy efficiency is another key advantage, as smart home systems allow optimising energy use, resulting in lower costs and a positive impact on the environment. The integration of environmentally oriented technologies can contribute to the creation of energy-efficient solutions. Security is also an important aspect in the

Ukrainian housing sector. Monitoring, video surveillance, and alarm systems can provide a high level of security for residents and their property. However, for the successful implementation of smart home systems in Ukraine, it is necessary to consider some challenges. Financial constraints, technical infrastructure, and data security issues require comprehensive investigation and development of appropriate strategies. In general, the introduction of smart home automation systems in the Ukrainian residential sector opens the way to improving the quality of life, optimising energy costs, and creating safe and comfortable housing. However, to achieve these goals, it is important to carefully consider all aspects and develop solutions that consider the specifics of the Ukrainian market and the needs of users.

Based on the results of recent study by C. Stolojescu-Crisan *et al.* (2021), the IoT-based smart home automation system is an innovative technology solution that combines a variety of devices and systems to increase efficiency and comfort in the home environment. This system involves the interaction of various devices, such as lighting, thermostats, video surveillance cameras, electrical appliances, and others that can be connected to the Internet and controlled via special applications or voice commands. One of the key advantages of such a system is the ability to remotely control the house. Users can turn devices on and off, adjust the temperature, monitor security, or even track power consumption, all using smartphones or other devices with network access. This approach allows residents to manage their homes conveniently and efficiently at any time and from any place. The data is consistent with the theses outlined in the previous section regarding the growing popularity and introduction of smart home systems. With the growing interest and adoption of such systems, there are questions about data privacy and security, as well as the need for standardisation. Ensuring reliability and protection from external threats becomes crucial for the further successful development of this technology, as it depends on the decision of consumers and investors to implement such innovative systems in their homes.

Turning to definition by B. Mustafa *et al.* (2021), a low-cost IoT-based smart home automation system opens up new opportunities for a wide range of users looking to improve their lives at an affordable price. This approach makes smart home technologies accessible to a wide range of consumers, providing the ability to automate basic home functions without significant costs. One of the key advantages of such a system is its ease of installation and use. The availability of the technology allows users to install and configure devices themselves, which makes it convenient to use even for those who do not have deep technical knowledge. Along with expanding accessibility, it is important to consider security and privacy issues. Low-cost systems may have limited protection measures against cyber threats, so the choice and configuration of devices are

crucial to ensure the security and privacy of users. Increased attention to these aspects becomes necessary in the context of the widespread use of technology in everyday life. Ensuring data security and protection is becoming an important task for solving potential threats and ensuring the reliability of systems in real-world operating conditions.

S. Venkatraman *et al.* (2021) determined that smart home automation based on voice control is becoming an important aspect of modern life, offering a secure and integrated approach to managing various devices and systems in the home. One of the main advantages of such a system is the ease of use – the user can interact with the home using voice commands, which ensures ease and efficiency of management. The use of voice control also contributes to the security of the smart home. The absence of the need for physical contact with remote controls or sensors reduces the risk of entering incorrect commands or unauthorised access. Such a system can be integrated with security devices, such as video surveillance systems or motion sensors, to instantly respond to events at home. These results confirm previous research, pointing out the importance of taking privacy issues into account and ensuring reliable protection of users' personal data in a high-tech smart home environment. Achieving full integration and security requires a comprehensive approach to data management, and improving cybersecurity technologies. Consideration of these aspects becomes a key to creating an enabling environment for the use and development of smart home systems, which ensures the reliability and confidentiality of information in this ecosystem.

Researchers H. Yar *et al.* (2021) showed in their study that smart home automation through the use of the peripheral computing and IoT paradigm represents a promising way to introduce innovation in modern households. The peripheral computing paradigm involves using the built-in computing resources of smart home devices to process and analyse data on-site, reducing the need to transfer large amounts of information to the cloud. This approach helps to increase the response rate of the system, because calculations are performed at the device level, which reduces delays and improves efficiency. In addition, the use of peripheral computing can contribute to ensuring data privacy and privacy, since sensitive information data remains on the device itself, without being transferred to external computing clouds. While agreeing with this view, it is important to consider security and standardisation aspects when implementing solutions in smart homes. This will ensure the compatibility and reliability of automated systems based on peripheral computing and IoT. Proper compliance with standards will avoid compatibility issues and ensure efficient operation of systems. Consideration of these aspects will ensure the safety and reliability of smart homes, increasing their suitability and convenience for users and contributing to the further development of this technology.

As noted by O. Taiwo *et al.* (2022), an advanced smart home management and security system based on the deep learning model marks a new stage in the development of modern technologies for households. The use of deep learning allows the system to analyse and interpret large amounts of data received from sensors and devices in real-time. This allows the system not only to respond to changes in the environment, but also to learn independently and improve its functions over time. The use of deep learning in smart homes can improve security systems, allowing the automatic recognition of abnormal situations and a timely response. In addition, such a system can adapt to unique user preferences, optimising resource usage and providing a higher level of comfort. When implementing such technologies, it is necessary to consider ethical and privacy issues, guaranteeing the protection of personal data and control over their use. In addition, the system must be resistant to cyber-attacks and have a high level of reliability, as it provides security and management of important aspects of the home environment. Careful consideration of these aspects will help prevent possible problems and ensure the effective functioning of smart systems, which will contribute to a comfortable and safe life in modern households.

M.J. Iqbal *et al.* (2021) determined that the introduction of smart home automation using intelligent electricity dispatching is an important step towards optimising energy consumption and management in domestic settings. This innovative system allows effectively regulating the use of electricity in the home, providing an optimal balance between comfort and energy efficiency. Intelligent power dispatching allows automatically distributing energy between different devices and systems in the home based on their needs and operating modes. For example, the system can automatically turn off electrical appliances during periods of low consumption or adjust the operation of heating and air conditioning systems for optimal energy consumption.

Among other things, attention should be paid to aspects of cybersecurity and data privacy protection when using such systems. Effective security measures and the definition of standards are crucial for the successful implementation of intelligent electricity dispatching in smart homes. Strict security measures and standards will help avoid possible threats to systems and ensure the reliability and safety of use in different households. Addressing these aspects is important for ensuring the stability and efficiency of the system and user confidence in the smart home.

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CONCLUSIONS

The development and implementation of smart home automation systems in the Ukrainian residential sector is an urgent and promising task that faces significant challenges and has powerful opportunities for further development. The study notes that the rapid development of technology and the growing interest in the concept of a "smart home" determine the need to explore opportunities and identify obstacles to the effective implementation of these technologies in modern life.

One of the key conclusions is that financial constraints can complicate the process of implementing smart home automation systems for many Ukrainians. It is necessary to actively work on developing more accessible and effective solutions to ensure broad public access to these technologies. Technical infrastructure, in particular the quality and stability of the Internet, is an important component for the full operation of smart home systems. For successful implementation, it is necessary to develop and improve infrastructure, in particular high-speed and stable Internet.

Data security is identified as one of the main concerns in the implementation of smart home systems. Protecting personal data and ensuring that smart home systems cannot be abused requires serious attention and balance in the development and operation of such systems. The lack of a single standard platform is defined as another important aspect that can affect the success of implementing smart home systems. It is important to work on standardisation to ensure compatibility and integration between different manufacturers. Smart technologies can have a positive impact on various aspects of life, including comfort, safety, and energy efficiency. However, for their successful implementation, it is necessary to develop and improve technologies, solve financial and infrastructure problems, ensure security and compliance with standards.

Areas for future research include investigation of the impact of smart home systems on environmental aspects and improving their energy efficiency, considering the specific conditions of the Ukrainian residential sector.

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CONFLICT OF INTEREST

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Розробка та впровадження системи автоматизації розумного будинку в умовах українського житлового сектору: виклики та перспективи

Павло Кузнецов

Магістр

Приазовський державний технічний університет

49000, вул. Гоголя, 29, м. Дніпро, Україна

<https://orcid.org/0009-0001-0762-9958>

Анотація. У зв'язку зі стрімким розвитком технологій та зростаючим інтересом до концепції «розумного будинку», дослідження є актуальним для визначення перешкод та можливостей, сприяючи ефективному впровадженню цих технологій в сучасне життя. Мета даного дослідження полягає в проведенні аналізу сучасного стану та визначенні можливостей розробки та впровадження систем автоматизації розумного будинку в українському житловому секторі для підвищення рівня комфорту, забезпечення безпеки та підвищення енергоефективності. Серед використаних методів слід зазначити аналітичний метод, метод класифікації, функціональний метод, статистичний метод, метод синтезу та інші. Результати дослідження розкривають глибокий вплив технологій на ефективність та безпеку розумного будинку. Під час проведення дослідження було проаналізовано сучасний стан систем автоматизації розумного будинку в українському житловому секторі. Були розглянуті сучасні методи кібербезпеки для захисту від потенційних загроз. Електронні ключі, включаючи технології Face Identification, відбитку пальця та голосового розпізнавання впроваджуються для забезпечення доступу та підвищення рівня безпеки у розумному будинку. Дослідження відкриває різноманітні методики, які використовуються у різних країнах для впровадження розумних будинків, де презентовано різні приклади реалізації та особливості їх розвитку. В результаті виявлено ключові технічні та фінансові виклики, які ставлять під сумнів ефективність впровадження таких систем. Окрім того, були розглянуті можливості оптимізації цих систем, враховуючи особливості ринку та інфраструктурні обмеження. Згідно з проведеним аналізом, були розроблені конкретні рекомендації щодо створення доступних та ефективних рішень для українських споживачів. На підставі цих рекомендацій можна зробити висновок, що, незважаючи на існуючі труднощі, впровадження систем розумного будинку в Україні має потенціал та перспективи. Однак, для досягнення повного успіху, важливо подолати технологічні виклики та врахувати фінансові можливості населення. Дослідження зробило вагомий внесок у розуміння факторів, що впливають на успішну імплементацію сучасних технологій у житловому секторі України, сприяючи практичному розвитку науки та надаючи конкретні висновки для можливостей впровадження систем автоматизації розумного будинку

Ключові слова: технології; енергоефективність; технічні методи; рекомендації; інфраструктурні обмеження