THE USAGE OF SMART CAMERAS IN SMART HOME

Radosław WOLNIAK[1*], Wies GREBSKI[2]

[1] Silesian University of Technology, Organization and Management Department, Economics and Informatics Institute; rwolniak@polsl.pl, ORCID: 0000-0003-0317-9811
[2] Penn State Hazletonne, Pennsylvania State University; wxg3@psu.edu, ORCID: 0000-0002-4684-7608
* Correspondence author

Purpose: The purpose of this publication is to present the usage of smart cameras in smart home.

Design/methodology/approach: Critical literature analysis. Analysis of international literature from main databases and polish literature and legal acts connecting with researched topic.

Findings: The integration of smart cameras into the fabric of smart homes signifies a revolutionary advancement in security, convenience, and efficiency. These technologically sophisticated devices, harnessing the power of artificial intelligence and machine learning, transcend traditional surveillance, providing a myriad of functionalities that redefine contemporary living. Primarily excelling in security, smart cameras enable real-time monitoring with features like facial recognition and object detection, empowering homeowners to swiftly identify potential threats and proactively enhance security measures. The seamless integration of smart cameras with other home automation devices establishes an interconnected ecosystem, enabling automated responses based on detected events and synchronized actions with smart door locks, sensors, and lighting systems. Additionally, smart cameras contribute to energy efficiency and resource management by analyzing occupancy patterns, optimizing HVAC systems, and addressing privacy concerns through customizable settings. However, challenges such as privacy and data security issues, false positives, internet connectivity dependency, and upfront costs must be navigated through regulatory frameworks, technological improvements, and user education. Despite these challenges, the substantial advantages of enhanced security, remote monitoring, and seamless integration position smart cameras as pivotal elements in the ongoing evolution of smart homes.

Originality/Value: Detailed analysis of all subjects related to the problems connected with the usage of smart cameras in smart home.

Keywords: Smart City, energy efficiency, smart home, smart house, digitalization, smart cameras

Category of the paper: literature review.

1. Introduction

Smart cameras play a pivotal role in the contemporary landscape of smart homes, contributing significantly to the evolution of home automation and security. These intelligent devices seamlessly integrate into the fabric of smart homes, offering a range of functionalities that go beyond traditional surveillance. In the realm of security, smart cameras provide homeowners with real-time monitoring capabilities, allowing them to keep a watchful eye on their property remotely. The integration of advanced technologies such as facial recognition and object detection enhances their effectiveness, enabling the identification of familiar faces and alerting homeowners to potential security threats (Alsaedi et al., 2023).

Beyond security, smart cameras contribute to the overall convenience and efficiency of smart homes. With features like two-way audio communication, homeowners can remotely communicate with family members, guests, or even delivery personnel. This not only facilitates interactive monitoring but also adds an additional layer of convenience by enabling communication without physical presence. Moreover, the integration of smart cameras with other smart home devices creates a holistic and interconnected ecosystem. For instance, smart cameras can collaborate with smart door locks, sensors, and lighting systems. This integration allows for automated responses based on detected events. For example, a smart camera identifying motion at the front door can trigger the smart door lock to send an alert or initiate a predefined action, enhancing both security and convenience (Chaudhari et al., 2023).

The purpose of this publication is to present the usage of smart cameras in smart home.

2. Smart cameras in smart home

Smart cameras have become an integral component of modern surveillance and security systems, revolutionizing the way we monitor and safeguard our surroundings. These advanced devices leverage cutting-edge technology to provide enhanced functionality and efficiency in diverse applications, ranging from public spaces to private residences. One of the primary advantages of smart cameras lies in their ability to incorporate artificial intelligence (AI) and machine learning algorithms (Wu et al., 2023). These sophisticated algorithms empower smart cameras to not only capture and record video footage but also analyze and interpret the visual data in real-time. This capability enables them to detect and respond to various events, such as intrusions, suspicious activities, or unauthorized access, with a level of accuracy and speed that traditional surveillance systems often struggle to achieve (Huda et al., 2024).

In the realm of public safety, smart cameras contribute significantly to the prevention and investigation of criminal activities. Their advanced analytics can identify anomalies, track individuals, and even recognize specific objects or behaviors. This proactive approach allows law enforcement agencies to respond swiftly to potential threats, enhancing overall security in public spaces such as airports, transportation hubs, and city centers. Moreover, smart cameras play a crucial role in industrial settings, where they can monitor production processes, ensure workplace safety, and identify defects in real-time. By leveraging machine vision, these cameras contribute to quality control efforts, reducing the likelihood of faulty products reaching the market and improving overall production efficiency (Raff et al., 2024).

In the retail sector, smart cameras enable businesses to analyze customer behavior and preferences. Retailers can use this information to optimize store layouts, enhance product placements, and personalize marketing strategies. Additionally, smart cameras assist in the prevention of theft and fraud by detecting suspicious activities and notifying security personnel promptly (Sobhani et al., 2023). In the realm of smart cities, these cameras are instrumental in traffic management, environmental monitoring, and urban planning. They can help alleviate congestion, improve emergency response times, and contribute to the development of sustainable urban environments. By collecting and analyzing data from various sources, smart cameras empower city planners to make informed decisions for the benefit of residents and visitors alike (Ramanujam et al., 2024).

Despite the numerous benefits, the widespread adoption of smart cameras has raised concerns about privacy and data security. As these devices continuously capture and process vast amounts of visual data, it is crucial to establish robust regulations and ethical frameworks to protect individuals' privacy rights and prevent misuse of the gathered information (Douha et al., 2023).

The application of smart cameras in smart homes extends to energy efficiency and resource management. Some smart cameras are equipped with advanced analytics that can identify patterns of occupancy within a home. This information can be utilized to optimize the operation of heating, ventilation, and air conditioning (HVAC) systems, contributing to energy savings and environmental sustainability. Privacy considerations are paramount in the context of smart home surveillance, and manufacturers have responded by incorporating features that prioritize user control. Homeowners can customize privacy settings, define areas that are off-limits for monitoring, and have the ability to disable cameras when desired (Patheja et al., 2023).

The usage of smart cameras in smart homes transcends conventional security measures, offering a holistic approach to modern living. Their integration with advanced technologies, coupled with seamless collaboration with other smart devices, positions them as essential components in the creation of intelligent, secure, and efficient home environments. As smart homes continue to evolve, smart cameras will likely play an increasingly central role in shaping the future of residential living (Afroz et al., 2024).

Table 1 contains descriptions of key features of smart cameras usage. This table provides a concise overview of key features associated with the usage of smart cameras, highlighting their diverse applications and the challenges related to privacy and data security (Ameur et al., 2023).

Table 1.
Key features of smart cameras usage

Key Features of Smart Cameras	Description
AI and Machine Learning	Smart cameras leverage advanced algorithms for real-time analysis of visual data. This enables them to identify and respond to specific events, such as intrusions or suspicious activities.
Real-Time Monitoring	These cameras provide instant monitoring capabilities, allowing for timely detection and response to security threats or unusual occurrences.
Event Recognition	The ability to recognize specific events, behaviors, or objects enhances the camera's functionality, aiding in crime prevention and investigation.
Proactive Security	By actively identifying potential threats, smart cameras contribute to proactive security measures, allowing for quicker response times and improved overall safety.
Industrial Applications	In industrial settings, smart cameras play a role in quality control, monitoring production processes, ensuring workplace safety, and identifying defects in real-time.
Retail Analytics	Smart cameras in retail environments analyze customer behavior, optimize store layouts, and contribute to theft prevention by detecting suspicious activities.
Traffic Management	Contributing to smart city initiatives, these cameras assist in traffic management by monitoring congestion, improving emergency response times, and aiding in urban planning.
Environmental Monitoring	Smart cameras in smart cities also contribute to environmental monitoring, collecting data for air quality, noise levels, and other parameters to support sustainable urban development.
Privacy Concerns	The widespread use of smart cameras has raised privacy concerns. Addressing these concerns requires establishing regulations and ethical frameworks to protect individuals' privacy rights and prevent misuse.
Data Security	With the continuous capture and processing of visual data, ensuring robust data security measures is imperative to prevent unauthorized access or misuse of the gathered information.
Wide-Angle Coverage	Smart cameras often have a wide field of view, allowing for comprehensive coverage and reducing the need for multiple cameras in a single area.
Pan-Tilt-Zoom (PTZ) Control	The capability to pan, tilt, and zoom provides flexibility in adjusting the camera's focus, enabling users to closely monitor specific areas of interest in real-time.
Low Light and Night Vision	Many smart cameras are equipped with low-light and night vision capabilities, ensuring effective surveillance even in challenging lighting conditions.
Cloud Integration	Integration with cloud services allows for remote access to video feeds, storage of footage, and facilitates data analysis and sharing across multiple locations.
Mobile Alerts and Notifications	Users can receive real-time alerts and notifications on their mobile devices, keeping them informed about security events or anomalies, even when they are away from the monitoring site.
Two-Way Audio	Some smart cameras feature two-way audio communication, enabling users to both listen to and speak with individuals within the camera's vicinity. This is useful for interactive monitoring and communication.
Facial Recognition	Advanced facial recognition technology allows smart cameras to identify and categorize individuals, providing an additional layer of security and access control.
License Plate Recognition	In traffic management and law enforcement applications, smart cameras can recognize and log license plate information, aiding in vehicle tracking and monitoring.
Heat Mapping	Retailers use heat mapping features to analyze customer traffic and engagement, helping optimize store layouts and product placements based on popular areas.
Gesture Recognition	Gesture recognition technology enables smart cameras to interpret human gestures, offering interactive control options and enhancing accessibility in certain applications.

Cont. table 1.

Object Tracking	Smart cameras can dynamically track and follow moving objects or individuals within their field of view, maintaining focus and providing continuous monitoring.
Edge Computing	Some smart cameras have onboard processing capabilities (edge computing), allowing them to perform analytics locally and reduce the need for constant data transmission to a centralized server.
Integration with IoT Devices	Integration with Internet of Things (IoT) devices enables smart cameras to collaborate with other smart devices, enhancing automation and control in smart home or industrial settings.
Customizable Analytics	Users can often customize analytics settings based on their specific needs, tailoring the smart camera's functionality to address particular security or monitoring requirements.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzeł et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

3. The advantages and problems of using smart cameras

The integration of smart cameras into smart home environments brings forth a multitude of advantages, elevating the overall functionality, security, and convenience of modern living. One of the foremost benefits is the heightened level of security that smart cameras provide (Dhaou, 2023). Equipped with advanced features such as facial recognition and object detection, these cameras offer real-time monitoring, enabling homeowners to identify and respond promptly to potential threats. Remote monitoring stands as another pivotal advantage, allowing homeowners to keep a vigilant eye on their property from virtually anywhere in the world. This capability not only fosters peace of mind but also empowers users to respond swiftly to security events or emergencies, irrespective of their physical location (Valencia-Arias et al., 2023).

The incorporation of two-way communication in smart cameras further enhances their utility (Hussain et al., 2023). This feature enables homeowners to interact with individuals within the camera's field of view, fostering interactive monitoring. Whether it's communicating with family members, guests, or even delivery personnel, this capability adds a layer of convenience and control to the smart home ecosystem (Chen et al., 2023). Smart cameras truly shine in their ability to seamlessly integrate with other smart devices. This integration facilitates automation and coordination between various components of the smart home, such as smart door locks, sensors, and lighting systems. The result is a synchronized response to events, contributing to both security and convenience in the smart home environment (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021; 2022).

Energy efficiency is another noteworthy advantage, with some smart cameras utilizing advanced analytics to identify occupancy patterns. This information can be leveraged to optimize the operation of heating, ventilation, and air conditioning (HVAC) systems, reducing energy consumption and promoting sustainability within the smart home. Customizable privacy

settings address concerns related to surveillance in the home (Tong et al., 2023). Homeowners have control over monitoring zones, can disable cameras as needed, and customize privacy preferences. This ensures that smart cameras align with individual privacy preferences, striking a balance between security and personal space (Rhode et al., 2023).

Real-time alerts and notifications keep homeowners informed of specific events detected by smart cameras, offering immediate feedback for proactive responses. Additionally, integration with cloud services ensures secure storage of video footage, remote access to recordings, and seamless data sharing across devices (Olabode et al., 2023). The analytical capabilities of smart cameras provide insights into occupancy patterns, enabling informed decisions about home automation, security settings, and resource management. This contributes to a more intelligent and responsive living environment in the smart home (Bsarir-Orzeł et al., 2023).

Lastly, the user-friendly installation and setup of smart cameras make them accessible to a broad range of users, encouraging widespread adoption and ensuring that the benefits of this technology are attainable for all those seeking to enhance their smart home experience (Hussain et al., 2023).

Table 2 highlighting the advantages of using smart cameras in smart home. This table outlines the diverse advantages associated with the use of smart cameras in smart homes, ranging from enhanced security and remote monitoring to energy efficiency and customizable privacy settings.

Table 2.
Advantages of using smart cameras

Advantage	Description
Enhanced Security	Smart cameras provide real-time monitoring and advanced security features, including facial recognition and object detection, to identify and respond to potential threats. This enhances the overall security of the smart home by offering comprehensive surveillance capabilities.
Remote Monitoring	Homeowners can remotely monitor their property through smart cameras, enabling them to keep an eye on their home, family, and belongings from anywhere in the world. This feature enhances peace of mind and allows for immediate response to security events or emergencies.
Two-Way Communication	Smart cameras with two-way audio capabilities facilitate communication between homeowners and individuals within the camera's vicinity. This feature is valuable for interactive monitoring, such as talking to family members, guests, or delivery personnel, enhancing convenience and control.
Integration with Smart Devices	Smart cameras seamlessly integrate with other smart home devices, allowing for automation and collaboration. Integration with smart door locks, sensors, and lighting systems enables coordinated responses to events, contributing to both security and convenience in the smart home environment.
Energy Efficiency	Some smart cameras use advanced analytics to identify patterns of occupancy, contributing to energy efficiency. This information can optimize the operation of HVAC systems based on actual usage, reducing energy consumption and promoting sustainability in smart home environments.
Customizable Privacy Settings	Homeowners have control over privacy settings, allowing them to define monitoring zones, disable cameras when needed, and customize privacy preferences. This ensures that smart cameras align with individual privacy preferences and address concerns related to surveillance in the home.

Cont. table 2.

Alerts and Notifications	Smart cameras provide real-time alerts and notifications to homeowners' devices when specific events, such as motion detection, are identified. This immediate feedback allows for prompt action in response to potential security breaches or other noteworthy occurrences in the smart home.
Integration with Cloud Services	Integration with cloud services enables secure storage of video footage, remote access to recordings, and the ability to share data across devices. This ensures that homeowners can access and manage their smart camera data conveniently and efficiently, even when away from home.
Occupancy Insights	Analytical capabilities of smart cameras can offer insights into occupancy patterns, helping homeowners make informed decisions about home automation, security settings, and resource management. This contributes to a more intelligent and responsive living environment in the smart home.
Easy Installation and Setup	Smart cameras are designed for user-friendly installation and setup, often allowing homeowners to integrate them into their smart home ecosystem with minimal effort. This ease of use encourages widespread adoption and ensures that the benefits of smart camera technology are accessible to a broad range of users.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzeł et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

Table 3 highlighting some of the common problems and challenges associated with the problems of using smart cameras in smart homes. This table outlines various problems associated with the usage of smart cameras in smart homes, along with detailed descriptions of each issue and suggested methods for overcoming or mitigating these challenges.

Table 3.
Problems of using smart cameras

Problem	Description	Methods of Overcoming
Privacy Concerns	The use of smart cameras raises significant privacy concerns, as they continuously capture and process visual data within the home. This can lead to discomfort or opposition from residents who are wary of constant surveillance and potential misuse of their personal information.	• Implementing robust privacy settings and features in smart cameras that allow users to control and customize the level of monitoring. • Educating users about the importance of privacy settings and providing clear information about how the collected data will be used.
Security Vulnerabilities	Smart cameras, like any connected device, are susceptible to hacking and security breaches. Unauthorized access to camera feeds can compromise the privacy and security of residents, potentially leading to unauthorized surveillance or data theft.	• Regularly updating firmware and software to address security vulnerabilities. • Implementing strong encryption protocols and secure authentication mechanisms. • Choosing reputable brands and manufacturers with a track record of prioritizing security in their smart camera products.
False Positives and Inaccurate Alerts	Smart cameras may generate false positives, triggering alerts for normal activities or irrelevant events. Inaccurate alerts can lead to user frustration and desensitization, diminishing the effectiveness of the smart camera in identifying genuine security threats.	• Fine-tuning motion detection algorithms and sensitivity settings to reduce false positives. • Utilizing advanced analytics and machine learning to improve the accuracy of event recognition. • Allowing users to customize alert preferences and thresholds to align with their specific needs.

Cont. table 3.

Dependency on Internet Connectivity	Smart cameras heavily rely on internet connectivity for real-time monitoring, remote access, and data storage in the cloud. Network outages or disruptions can result in the loss of crucial functionality and render the smart camera temporarily ineffective.	• Implementing local storage options or onboard memory in smart cameras to ensure continuous recording and functionality during internet outages. • Using redundant internet connections or backup systems to maintain connectivity. • Educating users about the importance of a stable and reliable internet connection.
High Upfront Costs	The initial investment in acquiring and installing smart cameras, along with associated smart home infrastructure, can be relatively high. This may pose a barrier to entry for some users who are deterred by the upfront costs associated with setting up a comprehensive smart home surveillance system.	• Offering more affordable smart camera options or bundles for users with budget constraints. • Explaining the long-term cost benefits, including potential savings on security services and insurance premiums. • Providing financing options or subscription plans to spread costs over time.
Compatibility Issues	Interoperability challenges may arise when integrating smart cameras with other devices or smart home platforms. Incompatibility issues can limit the seamless collaboration between different components, reducing the overall efficiency and automation potential of the smart home ecosystem.	• Ensuring that smart cameras adhere to industry standards for interoperability. • Choosing devices and platforms that support widely adopted communication protocols, such as Zigbee or Z-Wave. • Regularly updating firmware and software to address compatibility issues and improve integration capabilities.
Limited Field of View	The field of view of smart cameras may be limited, leading to blind spots or gaps in coverage. This limitation can reduce the effectiveness of surveillance, allowing potential security threats or events to go unnoticed if they occur outside the camera's range.	• Strategically positioning multiple smart cameras to cover a broader area and eliminate blind spots. • Selecting smart cameras with features like pan, tilt, and zoom (PTZ) for flexible coverage. • Regularly reviewing and adjusting camera placements based on the evolving needs of the smart home environment.
Limited Low-Light Performance	Smart cameras may struggle with capturing clear footage in low-light conditions, impacting their effectiveness during nighttime or in poorly lit areas. This limitation can compromise overall security and surveillance capabilities.	• Investing in smart cameras equipped with infrared (IR) or low-light vision capabilities for enhanced visibility in the dark. • Supplementing smart cameras with additional smart lighting solutions in key areas. • Ensuring regular maintenance, cleaning, and positioning of cameras to optimize low-light performance.
Data Privacy Concerns	The storage and transmission of video footage raise concerns about the privacy and security of the collected data. Unauthorized access or breaches could lead to the exposure of sensitive information, posing risks to the residents' privacy.	• Implementing end-to-end encryption for video data during storage and transmission. • Providing users with options for local storage to keep video footage within the confines of the home network. • Clearly communicating data privacy policies and compliance with relevant regulations to assure users of their information's security.

Cont. table 3.

Power Source Dependency	Smart cameras typically require a power source, and dependence on wired connections may limit their flexibility in terms of placement. Power outages or disruptions can also impact the continuous operation of smart cameras, leaving blind spots in surveillance coverage.	• Exploring battery-powered or solar-powered smart camera options for increased flexibility in placement. • Incorporating uninterruptible power supply (UPS) systems or backup power sources to mitigate the impact of power outages. • Strategically placing smart cameras near power sources while considering their field of view requirements.
Weather Resistance Challenges	Outdoor smart cameras may face challenges related to exposure to the elements, such as rain, snow, or extreme temperatures. These environmental factors can affect the camera's performance and durability over time.	• Choosing outdoor smart cameras with weather-resistant or weatherproof ratings. • Regularly maintaining and cleaning outdoor cameras to prevent damage from environmental factors. • Installing additional protective enclosures or housing for smart cameras to shield them from adverse weather conditions.
Complex Installation and Setup	Some users may find the installation and setup process of smart cameras to be complex or intimidating. Complicated procedures may discourage users from adopting smart camera technology or result in improper installations that impact their effectiveness.	• Providing user-friendly installation guides and tutorials. • Offering customer support services or professional installation assistance. • Simplifying setup procedures through intuitive mobile applications or software interfaces. • Incorporating plug-and-play features to streamline the initial configuration process.
Limited Facial Recognition Accuracy	While facial recognition technology is advancing, smart cameras may still encounter challenges in accurately identifying individuals, leading to false positives or negatives. This limitation can impact the reliability of facial recognition features for access control or security purposes.	• Regularly updating firmware to include improvements in facial recognition algorithms. • Offering customization options for users to fine-tune facial recognition settings based on their preferences. • Integrating additional biometric or multi-factor authentication methods to enhance overall security in conjunction with facial recognition.
Data Storage and Retrieval Issues	The continuous recording of video footage generates large amounts of data, leading to potential challenges in storage and retrieval. Retrieving specific footage quickly or managing storage capacity efficiently can become cumbersome, affecting the user experience.	• Providing options for cloud storage with scalable plans based on users' storage needs. • Implementing efficient video compression algorithms to optimize storage space. • Offering local storage solutions with expandable storage capacity. Incorporating intelligent search and retrieval features in smart camera software for streamlined access to specific footage.
Integration with Legacy Systems	Users with existing non-smart surveillance systems may face challenges integrating new smart cameras with legacy systems. Compatibility issues or differences in communication protocols can hinder a seamless transition to a unified and efficient smart home security setup.	• Choosing smart cameras and devices with open standards or compatibility with popular communication protocols. • Utilizing intermediary devices or hubs that act as bridges between legacy systems and smart technologies. • Seeking professional assistance or consulting with experts to identify and implement integration solutions based on specific system requirements.

Cont. table 3.

Legal and Regulatory Compliance	The use of smart cameras raises legal and regulatory considerations, such as adherence to data protection laws and privacy regulations. Failure to comply with these requirements can result in legal consequences and potential disputes, impacting the overall adoption and use of smart cameras in smart homes.	• Staying informed about and adhering to relevant data protection laws and privacy regulations. • Incorporating features in smart cameras that support compliance with privacy standards, such as privacy mode settings. • Providing clear documentation on legal obligations and privacy practices to educate users and ensure transparent compliance.

Source: (Gøthesen et al., 2023; Alsaedi et al., 2023; Chaudhari et al., 2023; Huda et al., 2024; Husain et al., 2023; Rhode et al., 2023; Bassarir-Orzeł et al., 2023; Tong et al., 2023; Chen et al., 2023; Douha et al., 2023; Sobhani et al., 2023).

4. Conclusion

The integration of smart cameras into the fabric of smart homes represents a transformative leap in the realms of security, convenience, and efficiency. These intelligent devices, armed with advanced technologies like artificial intelligence and machine learning, have evolved beyond traditional surveillance, offering a spectrum of functionalities that redefine modern living.

Smart cameras excel in the domain of security, providing real-time monitoring with features such as facial recognition and object detection. This not only enhances homeowners' ability to identify potential threats promptly but also fosters proactive security measures. Beyond security, the seamless integration of smart cameras with other smart home devices creates an interconnected ecosystem, allowing for automated responses based on detected events. For instance, collaboration with smart door locks, sensors, and lighting systems results in synchronized actions that enhance both security and convenience. Moreover, the advantages of smart cameras extend to energy efficiency and resource management. The ability to analyze occupancy patterns contributes to optimizing HVAC systems, promoting sustainability within the smart home. Privacy concerns are addressed through customizable settings, giving users control over monitoring zones and ensuring that smart cameras align with individual preferences.

However, the widespread adoption of smart cameras also introduces challenges. Privacy concerns and data security issues are paramount, necessitating the implementation of robust regulations and ethical frameworks. Security vulnerabilities pose risks of unauthorized access, emphasizing the importance of regular updates and strong encryption protocols. False positives, dependency on internet connectivity, and high upfront costs are challenges that require fine-tuning algorithms, alternative storage options, and accessible pricing strategies for broader user adoption. Compatibility issues, limited field of view, and low-light performance limitations underscore the need for industry standards, strategic camera placement, and enhanced hardware

features. The integration of smart cameras into legacy systems necessitates solutions such as open standards, intermediary devices, and professional assistance.

The advantages of smart cameras in smart homes are substantial, offering enhanced security, remote monitoring, and integration with other smart devices. The challenges, while significant, are addressable through technological advancements, user education, and industry collaboration. As smart homes continue to evolve, smart cameras are poised to play an increasingly central role in shaping the future of residential living.

References

1. Afroz, A., Khamari, S.S., Behera, R.K. (2024). Solar Powered Smart Home Automation and Smart Health Monitoring with IoT. *Lecture Notes in Networks and Systems, 728.* LNNS, 169-182.

2. Alsaedi, M.K., Riccio, R.E., Sharma, A., Romero, L.M., Sonkusale, S. (2023). Smart sensing flexible sutures for glucose monitoring in house sparrows. *The Analyst, 148(22),* 5714-5723.

3. Ameur, A., Berrada, A., Emrani, A. (2023).   Intelligent energy management system for smart home with grid-connected hybrid photovoltaic/gravity energy storage system. *Journal of Energy Storage, 72,* 108525.

4. Basarir-Ozel, B., Nasir, V.A., Turker, H.B. (2023). Determinants of smart home adoption and differences across technology readiness segments. *Technological Forecasting and Social Change, 197,* 122924.

5. Chaudhari, R.R., Joshi, K.K., Joshi, N., Pandey, A.K. (2023). Smart and ecofriendly intelligent house based on iot and simulation using a Cisco networking simulator. *Intelligent Sensor Node-Based Systems: Applications in Engineering and Science*, 259-273.

6. Chen, H., Zhang, Y., Wang, L. (2023). A study on the quality evaluation index system of smart home care for older adults in the community ——based on Delphi and AHP. *BMC Public Health, 23(1),* 411.

7. Dhaou, I.B. (2023). Design and Implementation of an Internet-of-Things-Enabled Smart Meter and Smart Plug for Home-Energy-Management System. *Electronics, 12(19),* 4041.

8. Douha, N.Y.-R., Renaud, K., Taenaka, Y., Kadobayashi, Y. (2023). Smart home cybersecurity awareness and behavioral incentives. *Information and Computer Security, 31(5),* 545-575.

9. Gajdzik, B., Wolniak, R., Nagaj, R. Grebski, W, Romanyshyn, T. (2023). Barriers to Renewable Energy Source (RES) Installations as Determinants of Energy Consumption in EU Countries. *Energies, 16(21),* 7364.

10. Gøthesen, S., Haddara, M., Kumar, K.N. (2023). Empowering homes with intelligence: An investigation of smart home technology adoption and usage. *Internet of Things (Netherlands), 24,* 100944.

11. Huda, N.U., Ahmed, I., Adnan, M., Ali, M., Naeem, F. (2024). Experts and intelligent systems for smart homes' Transformation to Sustainable Smart Cities: A comprehensive review. *Expert Systems with Applications, 238,* 122380.

12. Hussain, S., Azim, M.I., Lai, C., Eicker, U. (2023). New coordination framework for smart home peer-to-peer trading to reduce impact on distribution transformer. *Energy, 284,* 129297.

13. Hussain, S., Imran Azim, M., Lai, C., Eicker, U. (2023). Multi-stage optimization for energy management and trading for smart homes considering operational constraints of a distribution network. *Energy and Buildings, 301*, 113722.

14. Jonek-Kowalska, I., Wolniak, R. (2021). Economic opportunities for creating smart cities in Poland. Does wealth matter? *Cities*, *114*, 1-6.

15. Jonek-Kowalska, I., Wolniak, R. (2022). Sharing economies' initiatives in municipal authorities' perspective: research evidence from Poland in the context of smart cities' development. *Sustainability*, *14(4),* 1-23.

16. Olabode, S., Owens, R., Zhang, V.N., Shi, L., Chambers, D. (2023). Complex online harms and the smart home: A scoping review. *Future Generation Computer Systems, 149*, 664-678.

17. Patheja, P.S., Kalra, Y., Tyagi, A. Patheja, P.S., Kalra, Y., Tyagi, A. (2023). *Intelligent Sensor Node-Based Systems: Applications in Engineering and Science*, 155-175.

18. Raff, S., Rose, S., Huynh, T. (2024). Perceived creepiness in response to smart home assistants: A multi-method study. *International Journal of Information Management, 74,* 102720.

19. Ramanujam, E., Kalimuthu, S., Harshavardhan, B.V., Perumal, T. (2024). Improvement in Multi-resident Activity Recognition System in a Smart Home Using Activity Clustering. *IFIP Advances in Information and Communication Technology, 683.* AICT, 316-334.

20. Rohde, F., von Andrian, N., Lange, S. (2023). Threat, fixable or opportunity? Contested smart home futures in the German social media debate. *Energy Research and Social Science, 106,* 103306.

21. Sobhani, A., Khorshidi, F., Fakhredanesh, M. (2023). DeePLS: Personalize Lighting in Smart Home by Human Detection, Recognition, and Tracking, *SN Computer Science, 4(6),* 773.

22. Tong, Z., Mansouri, S.A., Huang, S., Rezaee Jordehi, A., Tostado-Véliz, M. (2023). The role of smart communities integrated with renewable energy resources, smart homes and electric vehicles in providing ancillary services: A tri-stage optimization mechanism. *Applied Energy, 351,* 121897.

23. Valencia-Arias, A., Cardona-Acevedo, S., Gómez-Molina, S., Gonzalez-Ruiz, J.D., Valencia, J. (2023). Smart home adoption factors: A systematic literature review and research agenda. *PLoS ONE, 18(10 October),* e0292558.

24. Wu, D., Feng, W., Li, T., Yang, Z. (2023). Evaluating the intelligence capability of smart homes: A conceptual modeling approach. *Data and Knowledge Engineering, 148*, 102218.