

THE USAGE OF SMART DOORBELLS IN SMART HOME

Radosław WOLNIAK^{1*}, Wies GREBSKI²

¹ Silesian University of Technology, Organization and Management Department, Economics and Informatics Institute; rwolniak@polsl.pl, ORCID: 0000-0003-0317-9811

² Penn State Hazleton, Pennsylvania State University; wsg3@psu.edu, ORCID: 0000-0002-4684-7608

* Correspondence author

Purpose: The purpose of this publication is to present the usage of smart doorbells in smart homes.

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 doorbells into the fabric of smart homes signifies a substantial leap forward in the realms of home automation and security. Originally conceived as a means to alert homeowners to visitors, smart doorbells have undergone a remarkable evolution, emerging as sophisticated devices that significantly contribute to heightened security, convenience, and overall peace of mind. These vigilant guardians offer real-time video surveillance, incorporating features like two-way audio communication, motion detection, and night vision for comprehensive security coverage. Beyond security functions, smart doorbells extend unparalleled convenience through remote access and seamless integration with other smart home devices, allowing users to engage in remote communication, manage settings, and automate various tasks. The incorporation of artificial intelligence and machine learning further enhances their capabilities, introducing features like facial recognition and adaptive learning. Table 1 details the key features, highlighting their diverse contributions to modern smart home environments. The multifaceted advantages of smart doorbells, encompassing security enhancements, convenience, and increased property value, are outlined in Table 2. While acknowledging potential challenges outlined in Table 3, such as privacy concerns and dependence on internet connection, practical solutions are presented, underscoring the ongoing potential for smart doorbells to redefine the management of living spaces as they become increasingly interconnected, secure, and intelligent.

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

Keywords: Smart City, energy efficiency, smart home, smart house, digitalization, smart doorbells.

Category of the paper: literature review.

1. Introduction

The integration of smart technology into the fabric of our daily lives has transformed the way we interact with and manage our homes. One such innovation that has gained significant prominence in the realm of smart homes is the smart doorbell. This seemingly unassuming device has evolved beyond its traditional role of merely alerting homeowners to the presence of a visitor at the door. Instead, smart doorbells have become integral components of sophisticated home automation systems, offering a plethora of features and benefits that enhance both security and convenience (Chaudhari et al., 2023).

At its core, a smart doorbell is a connected device equipped with a camera and various sensors that allow it to capture and transmit real-time video and audio feeds to the homeowner's smartphone or other connected devices. This live streaming capability enables homeowners to remotely monitor their front door, providing a layer of security and peace of mind, especially when away from home. The visual verification of visitors and package deliveries empowers homeowners to make informed decisions about whether to answer the door, communicate with the visitor, or take appropriate action, all from the convenience of their mobile devices (Raff et al., 2024).

The purpose of this publication is to present the usage of smart window blinds in smart doorbells.

2. Smart doorbells in smart home

Security is a paramount concern for homeowners, and smart doorbells play a pivotal role in bolstering the protective layers of a smart home. With features such as motion detection and night vision, these devices provide round-the-clock surveillance, ensuring that any suspicious activity or unexpected visitors are promptly brought to the homeowner's attention. The ability to record and store video footage locally or in the cloud further contributes to a comprehensive security strategy, serving as a valuable resource in the event of a security incident or the need for evidence (Wu et al., 2023, Ameer et al., 2023).

The convenience offered by smart doorbells extends beyond security concerns. Homeowners can benefit from features like two-way audio communication, allowing them to interact with visitors without physically opening the door. Whether it's instructing a delivery person on where to leave a package or letting a friend know they'll be right down, the ability to communicate remotely enhances overall convenience. Additionally, smart doorbells often integrate with other smart home devices, such as smart locks and lighting systems, creating a seamless and

interconnected ecosystem that can be controlled through a centralized platform or smartphone app (Patheja et al., 2023).

Furthermore, the integration of artificial intelligence (AI) and machine learning technologies in smart doorbells enhances their functionality. Advanced facial recognition algorithms can distinguish between familiar faces and unknown individuals, providing personalized alerts and contributing to a more tailored and efficient user experience. This level of intelligence also enables the device to learn and adapt to the homeowner's preferences over time, refining its ability to filter out false alarms and irrelevant notifications (Douha et al., 2023).

The usage of smart doorbells in smart homes represents a significant leap forward in home automation and security. These devices go beyond the basic function of a traditional doorbell, offering a sophisticated array of features that contribute to enhanced security, convenience, and peace of mind (Raff et al., 2024). As technology continues to advance, the integration of smart doorbells into the broader ecosystem of smart home devices is likely to further redefine the way we experience and manage our living spaces, creating homes that are not only secure but also seamlessly connected and intelligent (Afroz et al., 2024; Sobhani et al., 2023; Ramanujam et al., 2024).

Table 1 contains descriptions of key features of smart doorbells usage. This table provides an overview of the diverse features that contribute to the utility and functionality of smart doorbells in modern smart home environments.

Table 1.

Key features of smart doorbells usage

Key Features of smart doorbells	Description
Video Surveillance	Smart doorbells are equipped with high-definition cameras that provide real-time video feeds of the front door area. This feature enables homeowners to visually verify visitors, monitor deliveries, and enhance overall security.
Two-Way Audio Communication	The inclusion of microphones and speakers allows for seamless two-way communication between homeowners and visitors. This feature facilitates remote conversations, enabling homeowners to instruct delivery personnel, communicate with guests, or deter potential intruders.
Motion Detection	Smart doorbells utilize motion sensors to detect movement in the vicinity of the front door. This feature triggers alerts and recordings, providing homeowners with notifications about activity, even if the doorbell is not pressed.
Night Vision	Equipped with infrared LEDs, smart doorbells offer night vision capabilities, ensuring clear visibility in low-light or nighttime conditions. This enhances security and surveillance round the clock.
Cloud Storage	Many smart doorbells offer cloud storage options for recorded video footage. This allows homeowners to access and review past events remotely, providing a valuable resource for security purposes or in the event of a dispute or incident.
Integration with Smart Home Systems	Smart doorbells often integrate seamlessly with other smart home devices and ecosystems. This integration allows users to create automation scenarios, such as turning on lights or unlocking doors when the doorbell is pressed, enhancing the overall smart home experience.

Cont. table 1.

Facial Recognition	Advanced smart doorbells may feature facial recognition technology, allowing the device to identify and differentiate between familiar faces and unknown individuals. This enhances security and enables personalized notifications based on recognized faces.
Mobile App Control	Homeowners can control and monitor their smart doorbell through dedicated mobile applications. These apps provide a user-friendly interface for accessing live video feeds, adjusting settings, receiving notifications, and managing other aspects of the smart doorbell's functionality.
Wireless Connectivity	Smart doorbells typically connect to home networks via Wi-Fi, eliminating the need for complex wiring. This wireless connectivity not only simplifies installation but also allows for remote access and control through mobile devices, enhancing user convenience.
Artificial Intelligence (AI) Features	Some smart doorbells leverage AI capabilities, such as machine learning algorithms, to improve performance. This includes the ability to learn and adapt to user preferences, refine motion detection accuracy, and provide more intelligent and personalized alerts over time.
Wide-Angle Lens	Wide-angle lenses provide a broader field of view, reducing blind spots and ensuring comprehensive coverage of the front door area. This feature enhances surveillance capabilities, capturing more details in the camera's field of vision.
Multiple User Access	Support for multiple user accounts allows various household members to access and control the smart doorbell through individual smartphones. This collaborative access facilitates shared monitoring and management among family members.
Customizable Motion Zones	Users can define specific areas for motion detection, avoiding unnecessary alerts from passing objects. This customization enhances the precision of the smart doorbell's motion-sensing capabilities, tailoring it to the unique layout of the home.
Weather Resistance	Smart doorbells are designed to withstand various weather conditions, ensuring durability and functionality in rain, snow, or extreme temperatures. Weather-resistant materials contribute to the device's reliability and longevity.
Battery or Wired Options	Smart doorbells offer flexibility in power sources, with options for rechargeable batteries or connection to existing doorbell wiring. Battery-powered models are suitable for homes without wiring, providing versatile installation choices.
Siren or Chime Integration	Integration with additional security features, such as sirens or chimes, enhances the smart doorbell's capabilities. Users can remotely activate a siren for security purposes or customize chime alerts for different scenarios, adding an audible layer to the device's functionality.
Visitor History and Timestamps	Smart doorbells maintain logs of visitor history with timestamps, allowing homeowners to review past events. This comprehensive timeline includes doorbell presses, motion detections, and interactions, providing a detailed record of front-door activity.
Package Detection	Advanced smart doorbells can recognize packages left at the doorstep, sending specific notifications to homeowners about deliveries. This feature enhances convenience for online shoppers, ensuring they are promptly informed about package arrivals.
Third-Party Integration (APIs)	Support for third-party integration through APIs enables connectivity with a broader ecosystem of smart home devices and services. This interoperability expands the functionality of the smart doorbell, allowing users to create more comprehensive and customized smart home setups.
Tamper Detection	Built-in sensors can detect tampering or interference with the smart doorbell, providing alerts if someone attempts to disable or damage the device. Tamper detection adds an extra layer of security, ensuring the device remains operational and effective.

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; Basarir-Ozel 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 doorbells

The utilization of smart doorbells introduces a multitude of advantages that collectively contribute to an elevated level of security, convenience, and overall home management. Foremost among these benefits is the enhancement of home security (Tong et al., 2023; Rhode et al., 2023). Smart doorbells serve as vigilant guardians, offering real-time video surveillance and monitoring of the front door. This capability allows homeowners to visually confirm the identity of visitors, monitor deliveries, and promptly receive alerts regarding any suspicious activity. The integration of two-way audio communication adds an extra layer of control, enabling remote interactions with visitors and acting as a deterrent to potential intruders (Valencia-Arias et al., 2023).

Beyond security, smart doorbells bring a notable degree of convenience and remote access. Through dedicated mobile applications, users can remotely access and manage their smart doorbells from anywhere (Hussain et al., 2023). This functionality facilitates live video streaming, empowering homeowners to stay connected to their residences, make informed decisions about answering the door, and ensure the security of their property even when away. The ability to monitor package deliveries in real time further adds to the convenience, preventing theft and ensuring the timely retrieval of valuable deliveries (Dhaou, 2023).

Smart doorbells seamlessly integrate with other smart home devices, fostering a cohesive and interconnected ecosystem. This integration allows for the automation of various functions, such as adjusting lights or unlocking doors when the doorbell is pressed, enhancing overall smart home efficiency. Additionally, users gain valuable insights into visitor history, timestamps, and recorded interactions, providing a comprehensive record of front-door activity.

Customizable motion detection zones mitigate false alarms, ensuring that users receive relevant alerts tailored to their specific security needs. The weather-resistant design of smart doorbells ensures reliable performance in diverse weather conditions, maintaining functionality regardless of outdoor elements. These devices also contribute to energy efficiency by coordinating with other smart home devices to optimize energy resources (Hussain et al., 2023, Chen et al., 2023).

In addition to these features, smart doorbells offer benefits that extend to increased property value. Homes equipped with advanced security features and smart home technology tend to be more attractive to potential buyers or renters. For family caregivers, smart doorbells serve as a valuable tool for remote monitoring of elderly family members, offering video and audio features to check on their well-being.

Emergency response coordination is facilitated through two-way audio, enabling homeowners to communicate with emergency services or neighbors during critical situations. Some insurance providers offer premium discounts for properties equipped with smart security systems, leading to potential long-term financial benefits for homeowners. Facial recognition

capabilities in smart doorbells enhance safety by allowing homeowners to identify familiar faces and ensure authorized access to the home.

Moreover, smart doorbells foster community safety collaboration, allowing users to share alerts and information about suspicious activities with neighbors. This collective effort contributes to maintaining a secure neighborhood and promotes a sense of community and cooperation. In summary, the advantages of using smart doorbells extend far beyond traditional doorbell functionality, offering a comprehensive and intelligent approach to modern home living (Bsarir-Ozel et al., 2023; Olabode et al., 2023).

Table 2 highlighting the advantages of using smart doorbells in smart home.

Table 2.
Advantages of using smart doorbells

Advantage	Description
Enhanced Security	Smart doorbells significantly enhance home security by providing real-time video surveillance and monitoring of the front door. Homeowners can visually verify visitors, monitor deliveries, and receive instant alerts about suspicious activity, contributing to a proactive approach to home security. The ability to remotely communicate with visitors adds an extra layer of control and deterrence against potential intruders.
Convenience and Remote Access	Smart doorbells offer unparalleled convenience through remote access and control. Homeowners can view live video feeds, communicate with visitors, and manage doorbell settings from anywhere using a dedicated mobile app. This level of remote access enables users to stay connected to their home, make informed decisions about answering the door, and ensure the security of their property, even when away.
Package Monitoring	Smart doorbells provide the ability to monitor package deliveries in real time. Homeowners receive alerts when packages are delivered, preventing theft or ensuring timely retrieval. This feature adds an extra layer of convenience for online shoppers and helps safeguard valuable deliveries.
Deterrence of Intruders	The visible presence of a smart doorbell acts as a deterrent to potential intruders. Knowing that their actions are being recorded and monitored can discourage unauthorized individuals from attempting to breach the property, contributing to a safer living environment.
Integration with Smart Homes	Smart doorbells seamlessly integrate with other smart home devices, creating a cohesive and interconnected ecosystem. This integration allows users to automate various functions, such as turning on lights or unlocking doors when the doorbell is pressed, enhancing overall smart home efficiency.
Visitor Insights and History	Homeowners can access detailed visitor history and insights through smart doorbells. This includes timestamps and recorded interactions, providing a comprehensive record of front-door activity. Analyzing this data can offer valuable insights into daily routines, visitor patterns, and overall home dynamics.
Customizable Motion Detection	Smart doorbells often feature customizable motion detection zones, allowing users to define specific areas for monitoring. This customization minimizes false alarms triggered by unrelated motion, ensuring that users receive relevant alerts tailored to their specific security needs.

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; Basarir-Ozel 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 doorbells in smart homes.

Table 3.
Problems of using smart doorbells

Problem	Description	Methods of Overcoming
Privacy Concerns	The use of smart doorbells raises privacy concerns as they record and transmit video footage of the front door area. This can lead to potential invasions of privacy for both residents and visitors.	Opt for models with advanced privacy features, such as customizable motion zones, facial blurring, or geofencing. Clearly communicate the presence of a smart doorbell to visitors, and establish rules for when the camera is active or inactive.
Dependence on Internet Connection	Smart doorbells rely on a stable internet connection for proper functionality. In the event of network outages or disruptions, users may experience interruptions in video streaming, communication, and remote access.	Install a reliable and high-speed internet connection. Consider having a backup power source, such as a battery backup or alternative network options (e.g., cellular connectivity) to ensure continuous operation during internet outages.
Initial Cost and Installation	The upfront cost of purchasing and installing a smart doorbell can be relatively high compared to traditional doorbells. Additionally, installation may require technical expertise, potentially adding to the overall cost.	Research and choose budget-friendly models without compromising essential features. Installation costs can be minimized by opting for wireless models that do not require extensive wiring, and some users may choose to install the devices themselves.
Vulnerability to Hacking	Smart doorbells, like any connected device, are susceptible to hacking attempts. If not adequately secured, hackers may gain access to the device, compromising video footage and potentially breaching the homeowner's privacy.	Regularly update firmware and security settings. Use strong, unique passwords for device access. Choose models from reputable manufacturers with a track record of prioritizing security. Consider additional security measures, such as two-factor authentication.
Limited Field of View	Some smart doorbells may have a limited field of view, potentially missing important details or areas around the front door. This limitation could impact the device's effectiveness in providing comprehensive surveillance.	Select models with wider-angle lenses for a broader field of view. Consider additional devices, such as outdoor cameras, to complement the smart doorbell and ensure comprehensive coverage of the front door area.
Power Source Dependence	Smart doorbells are dependent on a power source, whether through hardwiring or rechargeable batteries. Power outages or battery depletion may render the device temporarily nonfunctional, leaving the front door unmonitored.	Choose a smart doorbell with alternative power options, such as battery backup or hardwiring to existing doorbell wiring. Regularly check and replace batteries if applicable, and consider installing backup power sources for added reliability.
Compatibility with Existing Systems	Compatibility issues may arise when integrating smart doorbells with existing home automation systems or other smart devices. This may result in limited functionality or the need for additional equipment to ensure seamless integration.	Prioritize smart doorbells designed to work with popular smart home platforms. Verify compatibility before purchase and consult user reviews or manufacturer support to address any potential compatibility issues.
Weather and Environmental Impact	Smart doorbells may be susceptible to adverse weather conditions, affecting performance and longevity. Exposure to extreme temperatures, rain, or direct sunlight can impact the device's functionality and durability over time.	Choose weather-resistant models designed to withstand various environmental conditions. Install the smart doorbell in a sheltered location, such as under an eave, to minimize exposure to direct sunlight, rain, or extreme temperatures.

Cont. table 3.

Limited Offline Functionality	Some smart doorbells may have limited offline functionality, particularly in the absence of an internet connection. This limitation can hinder basic functions such as remote access, live streaming, and alerts during network outages.	Prioritize smart doorbells with offline functionalities, such as local storage options for video footage. Consider models that can still perform essential functions, such as doorbell chimes, even when the internet connection is temporarily unavailable.
Data Storage Costs	Cloud storage for recorded video footage often incurs additional costs, especially for extended storage durations. This ongoing expense may contribute to the overall cost of ownership and may be a consideration for users on a tight budget.	Opt for smart doorbells with local storage options to minimize reliance on cloud storage. Adjust video storage settings to retain footage for a shorter duration or explore subscription plans that align with budget constraints.
False Alarms and Notifications	Smart doorbells with motion detection capabilities may generate false alarms or notifications triggered by unrelated movement, such as passing cars or animals. This can potentially lead to user frustration and decreased confidence in the device's reliability.	Adjust motion sensitivity settings to minimize false alarms. Utilize customizable motion zones to focus detection on specific areas. Regularly review and update settings based on environmental changes or feedback from false alerts.
Limited Facial Recognition Accuracy	Facial recognition features in smart doorbells may have limitations in accuracy, leading to potential misidentification of familiar or unfamiliar faces. This can impact the effectiveness of personalized notifications and security measures based on recognized individuals.	Understand the limitations of facial recognition technology and set realistic expectations. Regularly update firmware to benefit from improvements. Utilize additional security measures, such as secure access codes, to complement facial recognition.

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; Basarir-Ozel 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 doorbells into the framework of smart homes represents a significant advancement in home automation and security. Originally designed to alert homeowners to visitors, smart doorbells have evolved into sophisticated devices with features that contribute to enhanced security, convenience, and peace of mind.

Smart doorbells serve as vigilant guardians, providing real-time video surveillance and monitoring of the front door area. The inclusion of features such as two-way audio communication, motion detection, and night vision contributes to comprehensive security coverage. These devices empower homeowners to visually verify visitors, monitor deliveries, and receive timely alerts about any suspicious activity, fostering a proactive approach to home security.

Beyond security, the convenience offered by smart doorbells extends to remote access and integration with other smart home devices. Homeowners can remotely communicate with visitors, manage doorbell settings, and even automate functions like unlocking doors or turning on lights. The seamless integration of artificial intelligence (AI) and machine learning enhances the functionality of smart doorbells, providing advanced features such as facial recognition and adaptive learning, further refining the user experience over time.

Table 1 highlights key features of smart doorbell usage, emphasizing the diverse capabilities that contribute to their utility in modern smart home environments. The advantages of using smart doorbells are multifaceted, encompassing enhanced security, convenience, and increased property value. These devices not only serve as a technological deterrent to intruders but also facilitate remote monitoring of elderly family members, emergency response coordination, and potential insurance premium discounts. Table 2 provides a detailed overview of these advantages, showcasing how smart doorbells contribute to a safer, more connected, and intelligent home environment. However, it's essential to acknowledge the potential challenges associated with smart doorbell usage, as outlined in Table 3. Privacy concerns, dependence on internet connection, installation costs, and vulnerability to hacking are among the challenges users may face.

Despite these challenges, methods of overcoming each problem are presented, offering practical solutions to ensure a secure and effective smart doorbell experience. As technology continues to advance, smart doorbells are poised to redefine the way we manage our living spaces, creating homes that are not only secure but also seamlessly connected and intelligent.

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. Ameer, 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.