THE USAGE OF SMART VOICE ASSISTANT IN SMART HOME

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

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

Findings: he integration of smart voice assistants into smart homes promises a transformative shift in our daily lives, offering unparalleled convenience through hands-free control, efficient task automation, and personalized experiences. Despite these advantages, the evolution of this technology presents challenges, including privacy concerns, security vulnerabilities, and limitations in contextual understanding. Overcoming these obstacles necessitates a comprehensive approach, encompassing robust privacy settings, ongoing improvements in recognition algorithms, and a commitment to addressing biases. As technology advances, solutions such as offline capabilities, improved contextual understanding, and enhanced personalization become crucial for a seamless smart home experience. The need for industry collaboration, standardized practices, and the minimization of false triggers highlights the importance of a collective effort from developers, manufacturers, and users. Transparent communication, ethical considerations, and a focus on addressing challenges are paramount in creating a technologically advanced, secure, user-friendly, and inclusive smart home environment. This journey towards innovation underscores the importance of upholding values of privacy, security, and accessibility to unlock the true potential of smart living.

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

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

Category of the paper: literature review.

1. Introduction

The utilization of smart voice assistants in smart homes marks a significant leap forward in the realm of home automation, revolutionizing the way individuals interact with and manage their living spaces. These advanced systems, equipped with sophisticated voice recognition and natural language processing capabilities, bring forth a range of transformative applications. One of the central advantages lies in the hands-free convenience they offer. Users can seamlessly control an array of smart devices simply by articulating voice commands, eliminating the need for manual interaction. This streamlined approach enhances overall convenience and accessibility, particularly for individuals with mobility challenges. Efficiency is a cornerstone of smart voice assistant usage in smart homes. These systems excel in automating routine tasks, from setting reminders and creating shopping lists to managing daily schedules. By doing so, they not only save time but also contribute to increased productivity in daily activities (Patheja et al., 2023).

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

2. Smart voice assistant in smart home

Smart voice assistants have emerged as revolutionary technologies that seamlessly integrate into our daily lives, transforming the way we interact with and control our devices (Chen et al., 2023). These sophisticated virtual companions, powered by advanced artificial intelligence (AI) algorithms, have evolved from basic voice recognition systems into versatile and intuitive digital assistants (Olabode et al., 2023). At the core of these smart voice assistants is natural language processing (NLP), a branch of AI that enables machines to comprehend and respond to human speech in a manner that feels organic and conversational. This breakthrough technology has paved the way for a more intuitive and user-friendly interaction with devices, eliminating the need for cumbersome interfaces and manual inputs (Afroz et al., 2024).

One of the key features that distinguish smart voice assistants is their ability to perform a diverse range of tasks through voice commands. Whether it's setting reminders, sending messages, making calls, or even controlling smart home devices, these assistants have become virtual personal assistants that cater to our needs with just a spoken word. The seamless integration with various applications and services has made them an indispensable part of our daily routines (Gajdzik et al., 2023; Jonek-Kowalska, Wolniak, 2021; 2022). Moreover, the continuous learning capabilities of smart voice assistants contribute to their adaptability and personalized user experience. Through machine learning, these assistants can understand user

preferences, adapt to speech patterns, and provide increasingly accurate and relevant responses over time (Tong et al, 2023). This dynamic learning process enhances the overall user experience, making the interaction more personalized and efficient (Ameur et al., 2023).

In addition to their role as personal assistants, smart voice technologies have found applications in various industries, ranging from healthcare to education. In healthcare, they can be utilized to provide information, monitor health metrics, and even offer emotional support. In education, these assistants can facilitate learning by answering queries, providing information, and offering interactive lessons (Bsarir-Ozel et al., 2023). Security and privacy concerns have been significant considerations in the development of smart voice assistants (Rhode et al., 2023). Manufacturers have implemented robust security measures to safeguard user data and ensure that voice recordings are handled with the utmost confidentiality. Nevertheless, ongoing discussions and improvements in privacy policies are essential to address the evolving challenges associated with these technologies (Valencia-Arias et al., 2023).

Looking ahead, the future of smart voice assistants holds even more exciting possibilities (Hussain et al., 2023). As technology advances, we can anticipate enhanced contextual understanding, more natural conversations, and increased integration with emerging technologies like augmented reality and the Internet of Things (IoT). The evolution of these assistants is bound to reshape the way we interact with our digital environments, fostering a more connected and efficient lifestyle (Dhaou, 2023).

Table 1 contains descriptions of key features of smart voice assistance 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.

Table 1.
Key features of smart voice assistance usage

Key Features of Smart Voice Assistance	Description
Voice Recognition	Smart voice assistants utilize advanced voice recognition technology to understand and interpret spoken commands, allowing for hands-free interaction.
Natural Language Processing	These systems can comprehend and respond to natural language, enabling users to communicate with the assistant in a more conversational manner.
Task Automation	Smart voice assistants can perform various tasks on command, such as setting reminders, sending messages, or controlling smart home devices.
Information Retrieval	Users can ask the assistant for information on a wide range of topics, and it will provide relevant and up-to-date information from the internet.
Smart Home Integration	Integration with smart home devices enables users to control lights, thermostats, security systems, and more, using voice commands.
Calendar Management	Users can schedule appointments, set reminders, and check their calendar using voice commands, enhancing productivity and organization.
Multimodal Interaction	Some smart assistants support multimodal interaction, combining voice commands with visual feedback on devices with screens, such as smartphones.
Language Translation	Translation capabilities allow users to ask for translations or have real-time conversations in different languages using the voice assistant.

Cont. table 1.

Personalized Responses	Smart voice assistants can learn user preferences over time, providing personalized responses and recommendations based on individual habits and needs.
Accessibility Features	These features cater to users with disabilities by providing hands-free interaction, dictation, and accessibility settings for a more inclusive experience.
Continuous Learning	Many voice assistants continuously learn and improve their capabilities through machine learning, adapting to user preferences and evolving over time.
Voice Recognition	Advanced technology for accurate and reliable voice input recognition.
Natural Language Processing	Understanding and interpreting natural language, allowing for more intuitive and conversational interactions.
Task Automation	Automating tasks such as setting alarms, creating to-do lists, sending emails, or ordering items online through voice commands.
Information Retrieval	Access to a vast amount of information, providing answers to general knowledge questions, news updates, weather forecasts, and more.
Smart Home Integration	Seamless control of smart home devices like lights, thermostats, locks, and cameras using voice commands.
Calendar Management	Scheduling events, setting reminders, and checking calendar appointments with voice prompts.
Multimodal Interaction	Integration with screens for visual feedback, enabling users to see and interact with information in addition to voice commands.
Language Translation	Translating languages on the fly, facilitating communication across language barriers.
Personalized Responses	Customized interactions based on user preferences, history, and context, providing a more tailored and user-centric experience.
Accessibility Features	Voice assistants offer accessibility options, including voice commands for users with mobility issues and screen-reading capabilities for the visually impaired.
Continuous Learning	Machine learning algorithms allow the voice assistant to adapt and improve over time, learning from user interactions and evolving its capabilities.
Entertainment	Playing music, recommending movies, telling jokes, and engaging in casual conversations to provide entertainment and enhance user experience.
Location-Based Services	Utilizing location data for context-aware assistance, such as finding nearby restaurants, navigating routes, and providing location-specific information.
Integration with Third-Party Apps	Connecting with external applications and services to expand functionality, like ordering food, calling a ride-sharing service, or checking social media.
Security and Privacy Features	Implementing measures to safeguard user data and privacy, including voice recognition profiles and options to control data sharing.
Voice Modulation and Emotion Recognition	Some systems can recognize and respond to changes in voice modulation and emotion, providing a more nuanced and empathetic interaction.

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 voice assistant

Smart voice assistants have ushered in a new era of convenience and efficiency within the realm of smart homes. Their integration offers a myriad of advantages, fundamentally reshaping how individuals interact with and manage their living spaces. Foremost among these benefits is the hands-free convenience that smart voice assistants bring to the table. Users can seamlessly control a spectrum of smart devices, adjusting lighting, thermostats, and other connected elements through effortless voice commands, eliminating the need for physical interaction (Alsaedi et al., 2023).

Efficiency is another hallmark advantage. These assistants excel at automating routine tasks, from setting reminders and creating shopping lists to managing daily schedules. This not only streamlines day-to-day activities but also enhances overall productivity. Instant information retrieval is a key forte, allowing users to quickly access a wealth of information on demand. Whether checking the weather forecast, receiving news updates, or accessing real-time data, users can retrieve information simply by posing a question, eliminating the need for manual device checks (Chaudhari et al., 2023).

Enhanced home security is achieved through seamless integration with security systems, cameras, and smart locks. Voice commands provide quick access to security features, contributing to an enhanced sense of safety and control. The ability to personalize living environments stands out as a distinctive advantage. Users can tailor their spaces based on individual preferences, adjusting the thermostat, changing lighting colors, or setting up personalized routines (Huda et al., 2024).

Seamless device integration characterizes smart voice assistants, as they effortlessly unite with a diverse array of smart devices and platforms. This integration creates a unified ecosystem where users can control and manage various aspects of their homes through a single, voice-activated interface. Accessibility is a key consideration, particularly for individuals with mobility challenges or disabilities. The hands-free nature of voice control ensures inclusivity, allowing everyone in the household to easily interact with and benefit from smart home features (Wu et al., 2023).

Energy efficiency receives a boost through voice commands that enable users to optimize energy consumption. Controlling smart thermostats, lights, and appliances not only contributes to a more eco-friendly home but also aids in reducing energy costs. Remote control and monitoring add an extra layer of convenience and peace of mind. Whether away on vacation or at the office, users can stay connected to their homes through voice commands, enhancing overall control and security (Sobhani et al., 2023).

The intuitive nature of home automation facilitated by natural language commands makes operating complex systems more user-friendly. This ensures that individuals of all technological backgrounds can easily navigate and utilize the smart home environment. Increased productivity is a byproduct of smart voice assistants, allowing users to perform tasks efficiently, such as adding calendar events or creating reminders. This efficiency frees up time to focus on other activities and ultimately boosts overall productivity (Raff et al., 2024).

Multi-user recognition enhances the user experience by allowing smart voice assistants to recognize different users within a household. This feature offers personalized responses and tailored experiences for each family member. Integration with third-party apps extends the functionality of smart voice assistants, offering a broader range of capabilities and services to users (Ramanujam et al., 2024).

Continuous updates and improvements from manufacturers ensure that smart voice assistants remain up-to-date, secure, and capable of meeting evolving user needs. This commitment to innovation ensures that the smart home system continually evolves to enhance the user experience (Douha et al., 2023).

Table 2 highlighting the advantages of using smart voice assistant in smart home. These advantages showcase the transformative impact of smart voice assistants in creating more efficient, convenient, and personalized smart home environments.

Table 2.
Advantages of using smart cameras

Advantage	Description
Hands-Free Control	Users can control smart home devices, such as lights, thermostats, and locks, without the need for physical interaction, enhancing convenience.
Voice-Activated Entertainment	Enjoy seamless control of entertainment systems, including playing music, adjusting volume, or even selecting and streaming content using voice commands.
Efficient Task Automation	Automate routine tasks like setting timers, creating shopping lists, and managing daily schedules, making daily activities more streamlined and efficient.
Quick Information Retrieval	Obtain instant information on weather updates, news, and other real-time data by simply asking the voice assistant, eliminating the need to check devices manually.
Enhanced Home Security	Integrate voice commands to control security systems, cameras, and door locks, allowing users to monitor and secure their homes easily.
Personalized Environment	Adjust smart home settings based on individual preferences, creating a personalized and comfortable living environment for each household member.
Seamless Integration with Devices	Voice assistants seamlessly integrate with a wide range of smart devices, providing a unified platform for controlling and managing various aspects of the home.
Accessibility for All Users	Voice control enhances accessibility for individuals with mobility challenges or disabilities, offering a more inclusive smart home experience.
Energy Efficiency	Optimize energy consumption by controlling smart thermostats, lights, and appliances with voice commands, contributing to a more energy-efficient home.
Remote Control and Monitoring	Monitor and control smart home devices remotely using voice commands, providing convenience and peace of mind, especially when away from home.
Intuitive Home Automation	Simplify the operation of complex home automation systems by using natural language commands, making it more user-friendly and accessible to everyone.
Increased Productivity	Execute tasks efficiently, such as adding calendar events or creating reminders, allowing users to focus on other activities and enhance productivity.
Multi-User Recognition	Voice assistants can recognize different users in a household, providing personalized responses and tailored experiences for each family member.
Integration with Third-Party Apps	Connect with various third-party applications, expanding the capabilities of smart voice assistants and enabling a broader range of functionalities.
Continuous Updates and Improvements	Manufacturers regularly release updates, adding new features and improving performance, ensuring that the smart home system remains up-to-date and secure.

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 voice assistant 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 voice assistant

Problem	Description	Methods of Overcoming
Privacy Concerns	Users may express concerns about the privacy of their personal data, as voice assistants typically process and store voice recordings.	- Implement robust privacy settings that allow users to control data sharing preferences. - Regularly update privacy policies and communicate them transparently. - Develop local processing capabilities to limit data sent to the cloud.
Security Vulnerabilities	Smart voice assistants can be susceptible to hacking or unauthorized access, potentially exposing sensitive information or enabling malicious control over connected devices.	- Regularly update software and firmware to patch security vulnerabilities. - Implement strong authentication methods, such as voice recognition or biometrics. - Educate users on the importance of strong passwords and security practices.
Inaccuracy in Voice Recognition	Voice assistants may struggle to accurately recognize and interpret user commands, leading to frustration and diminished user experience.	- Continuously improve and update voice recognition algorithms through machine learning. - Provide options for users to train the system on their voice for better accuracy. - Incorporate contextual clues to enhance understanding of ambiguous commands.
Limited Understanding of Context	Voice assistants may lack contextual understanding, making it challenging to carry on complex or multi-step conversations. Misinterpretation of context can result in incorrect responses.	- Invest in natural language processing advancements to improve contextual understanding. - Implement machine learning models that consider historical user interactions for more accurate context recognition. - Allow users to provide additional context or clarification during interactions.
Dependency on Internet Connectivity	Many voice assistants rely on a stable internet connection for processing voice commands, which can be a limitation in areas with poor connectivity or during internet outages.	- Develop offline capabilities to handle basic commands without an internet connection. - Prioritize the use of local processing to reduce dependence on cloud-based services. - Educate users on optimizing their home network for a more reliable connection.
Device Compatibility Issues	Compatibility issues may arise when integrating voice assistants with various smart home devices, especially if they come from different manufacturers or use different communication protocols.	- Encourage device manufacturers to adhere to common industry standards for seamless integration. - Regularly update voice assistant software to support new devices and protocols. - Provide comprehensive compatibility lists and user guides for easy setup and troubleshooting.
False Triggers and Unintended Activation	Voice assistants may be triggered unintentionally by background noise or phrases that sound similar to wake words, leading to unintended activation and potential privacy concerns.	- Allow users to customize wake words to reduce false triggers. - Implement advanced audio processing algorithms to filter out background noise. - Incorporate contextual analysis to distinguish between intentional and unintentional activation.
Lack of Personalization for Multiple Users	Voice assistants may struggle to differentiate between multiple users, leading to a less personalized experience for each household member.	- Invest in robust multi-user recognition systems based on voice, biometrics, or other identifiers. - Allow users to create individual profiles with personalized preferences. - Continuously update algorithms to adapt to changing user patterns and preferences.
Ethical and Bias Concerns	Voice assistants may unintentionally perpetuate biases present in training data, resulting in biased responses or reinforcing stereotypes.	- Regularly audit and review training data for biases and diversity. - Implement ethical guidelines for content creation and response generation. - Encourage diverse and inclusive development teams to minimize unintentional biases

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 voice assistants into smart homes offers a multitude of advantages, transforming the way we interact with and manage our living spaces. The hands-free convenience, efficiency in task automation, and personalized experiences contribute to a more streamlined and enjoyable daily life. However, these advancements come with their set of challenges. Privacy and security concerns, potential inaccuracies in voice recognition, and limitations in contextual understanding represent significant hurdles in the widespread adoption of smart voice assistants. Overcoming these challenges requires a multi-faceted approach, including robust privacy settings, continuous improvement in recognition algorithms, and a commitment to addressing biases and security vulnerabilities.

As technology continues to evolve, solutions such as offline capabilities, improved contextual understanding, and enhanced personalization for multiple users are crucial to ensuring a seamless and reliable smart home experience. Device compatibility and minimizing false triggers further underscore the importance of industry collaboration and standardized practices. In navigating the future of smart homes, it is imperative for developers, manufacturers, and users alike to work together. Transparent communication, ethical considerations, and a dedication to addressing the identified challenges will be essential in fostering a smart home environment that is not only technologically advanced but also secure, user-friendly, and inclusive. As we continue on this technological journey, the pursuit of innovation must be accompanied by a commitment to the values of privacy, security, and accessibility to truly unlock the potential of smart 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.