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The Role of Artificial Intelligence in Smart Homes: A Survey-Based Study on Adoption, Problems, and Expectations

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Abstract:

Smart homes have gradually become a key factor in modern living, and AI has played an increasingly important role in making smart homes more useful, automated, and personalized. Based on the context, we set out to understand what people believed about consumer adoption of AI-powered smart homes, i.e., perceptions about current adoption/usage; existing difficulties and shortcomings of AI-powered smart homes adoption/usage; and expectations regarding the usage of this new technology in the future. Based on surveying 75 people via questionnaire and reviewing previous literature, we obtained these results below. People involved in the questionnaires showed a relatively high rate of smart home ownership and had also experimented with different functions of smart homes, with 89% using at least one such product. The most dominant reason for them to accept such product types was convenience with use and voice control being rated as the highest functions. Nevertheless, consumers felt its notable shortcomings among future intelligent home potential users: nearly half encountered various types of incompatibility issues of products (56%), instability of usage (50%), privacy violation risks and fears about data leaks (40%), while another 38% noticed exorbitant price levels. Simultaneously, they looked forward towards a variety of developments in this area, e.g., more personalization functions (e.g., personally-designed scenarios such as a Smart Home that dims the lights for you and lowers the room's temperature toward bedtime for the ideal body temperature range, 77%) and linking local communities' services to future technologies used within smart homes can greatly enrich the consumer experience (69%). Insights mentioned were found by looking further into the reasons for acceptance/difficulties/detriments of smart home technology based upon prior related research efforts; it demonstrated that although AI is helpful in enabling consumer lifestyles, it can better assist the consumer community as we move towards developing

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technologies around the core function areas, as outlined below, e.g., it will improve the existing drawbacks which we discussed above (such as guaranteeing cross-device compatibility, eliminating unstable features during usage, minimizing costs and charges of data usage, etc.), which would represent an opportunity in allowing artificial intelligence technologies to create benefits and advantages for the general populace through its continued application across diverse fields from home electrical appliances, civic infrastructure services (telecoms) to finance and insurance operations. Though minimal, sample populations within any field are not equal to all (not very many responses of older age participants were observed), these insights could help researchers to further examine smart home-related behavior factors among consumers henceforth as well as inform ongoing smart home innovation, especially AI-powered automation technology designs, directions of improvement accordingly.

Keywords: Artificial Intelligence, Smart Homes, Consumer Perceptions, AI Adoption, Data Privacy, Personalised Smart Scenes.

1. Introduction

A smart home is defined as a home that is automated, and home automation refers to the process of achieving a smart home. Smart homes can facilitate consumers' living experience and quality at home, providing convenience and energy savings. However, smart homes still face issues such as poor privacy protection, insufficient intelligence, and high costs, which hinder their development. For example, Vardakis et al. (2024) reviews the security challenges, threat types, and protection mechanisms of IoT technology in smart home environments, and mentions that these existing problems have to some extent hindered the development of smart homes.

To address these issues, some research has utilized AI to attempt to solve security threats and user experience problems. According to the systematic literature review by Brincoveanu et al. (2024), this study focuses on AI-driven sustainability assistance systems in smart home environments. Through the analysis of 60 articles, it proposes nine key patterns and explores future research directions. In deeper machine learning, privacy, security, manipulability, and personalization will all be improved. Previous studies have mostly focused on the technical functions and single-device impacts of smart homes, but have rarely explored how the integration of AI empowers smart homes or conducted in-depth research on people's attitudes towards it. To fill this gap, this study first uses literature and expert interviews to sort out the dimensions of AI empowerment, and then conducts a mixed study using questionnaires and interviews, aiming to clarify the AI empowerment path and understand people's attitudes, providing references for product optimization.

2. Literature Review

This section will explore the existing knowledge system in the field of the integration of artificial intelligence and smart homes, with a focus on key technical principles such as intelligent perception, autonomous decision-making, human-computer interaction, and system integration. As smart homes are currently evolving towards being more adaptive, predictive, and seamlessly interconnected, it is crucial to understand the core role of artificial intelligence in environmental understanding, user behavior analysis, and device coordination. This review references academic research and typical product cases to provide a systematic perspective. It will cover three main areas: (1) traditional smart home technology and limitations, (2) AI applications in smart homes, (3) future trends in smart

homes. Through the cross-analysis of the technology stack and user needs, the aim is to present a comprehensive overview that emphasizes both technology and humanistic aspects.

2.1 Traditional Smart Home Technology and Limitations

Traditional smart home technologies have centered their development on sensor networks and automation systems. In the early phase, the focus was largely on single-device control and basic sensor uses—capabilities limited to fundamental functions like switching devices on or off. As time progressed, IoT technology facilitated the creation of local sensor networks; through protocols such as Wi-Fi, these networks enabled simple coordination across multiple devices, and rule engines were also introduced to refine energy management. The addition of cloud platforms further expanded functionality, allowing for remote control and data storage.

These traditional systems hold clear advantages: they excel at basic environmental monitoring, enhance safety, and deliver initial energy optimization. What's more, they are easy for users to operate and maintain high stability. Yet their drawbacks are notable: they depend on fixed rules, leaving them unable to adjust to shifts in user behavior; device protocol inconsistencies lead to compatibility problems; data processing stays confined to storage and basic feedback loops; and security and privacy risks persist.

To overcome these limitations, intelligent technologies offer solutions. By analyzing user data, they can forecast needs and enable adaptive control; by digging deep into data value, they can anticipate demands; and by adopting approaches like federated learning, they can strengthen security and privacy protection. In doing so, they elevate the system's intelligence and tailor it more closely to individual user needs.

2.2 AI Application in Smart Homes

AI can empower traditional smart home systems across multiple dimensions, enhancing their intelligence and personalization. From the perspective of user behavior prediction and environmental adjustment, AI uses machine learning to analyze historical user data—such as weather, date, and device usage frequency—to predict user needs. Also, CNN-based behavior recognition can interpret user scenarios and adapt environmental parameters accordingly. In terms of health management, Samad Sepasgozar shows that AI, with the help of smart devices such as health wearables, monitors user health data like heart rate and sleep patterns in-text citation. It can also provide personalized recommendations based on in-home activities and even support the transmission of telemedicine-related data. Constantin Brîncoveanu notes that AI can integrate health data to assist with health management. Regarding voice interaction, Xiao Guo demonstrates that AI-driven natural language processing enhances the intelligence of voice assistants, allowing users to interact with devices using natural language and enabling cross-device command parsing, thereby overcoming the limitations of traditional interaction methods.

In summary, current researches demonstrate that AI can significantly enhance the performance of smart home systems in behavior prediction, health monitoring, and natural language interaction. However, there are issues such as easy privacy leakage, high cost, and potential system errors.

2.3 Future Trend in Smart Homes

Future smart home systems will evolve into a fully autonomous and context-aware new stage, driven by the deep integration of AI and IoT. AI leverages IoT sensors to collect real-time data on the environment, devices, and user behavior. Combined with big data analytics, it builds dynamic user profiles to enable automated services such as "adjusting room temperature based on commuting habits" or "activating home appliances in anticipation of the user's return" AI can also be more closely integrated with energy conservation and sustainable development, such as dynamically adjusting energy consumption, optimizing photovoltaic power generation and energy storage systems, and reducing carbon emissions. AI can achieve more intelligent human-computer interaction, not only limited to language, but also proactively provide services based on gestures, human emotional states, and physical conditions. For example, if it detects a low body temperature, it can automatically increase the air conditioning temperature.

However, several challenges remain in this development. Regarding data privacy, the vast amount of behavioral and health data collected is vulnerable to leakage, necessitating enhanced security measures such as federated learning to safeguard data. In terms of system security, the growing number of IoT devices expands the attack surface, requiring AI-powered real-time detection of abnormal access. For device interoperability, protocol differences between brands still hinder seamless integration, calling for unified standards to achieve cross-brand collaboration. Only by addressing these issues can AI and IoT truly drive the transformation of smart homes.

In conclusion, artificial intelligence technology has been preliminary combined and applied in smart homes, and can improve consumers' housing experience to a certain

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extent. It has also provided initial help in terms of safety and energy conservation. However, the lack of integration between AI and geospatial data, the absence of key technologies for comprehensive system integration, the scarcity of energy management and healthcare related products, and the absence of unified safety standards are still some existing problems. In response to the insufficient integration of AI and geospatial data, a combined technology framework should be developed; in light of the lack of key system integration technologies, adaptive technologies need to be researched and developed; in view of the scarcity of products, enterprises are encouraged to innovate and develop; regarding the lack of security standards, a unified standard should be established as soon as possible. This article aims to explore the popular features of smart homes that have not yet been launched, as well as whether existing problems can be solved by AI in the future.

3. Methodology

The objective of this research is to investigate the existing problems of smart homes and the new functions and technologies that consumers expect. It further aims to examine if existing or already proposed AI can address the existing problems. To reach this goal, both primary and secondary research was used in this study. In the primary research, a questionnaire was designed and distributed to understand the subjective perception of consumers. The secondary research involved reviewing academic literature through Google Scholar was used to identify advanced AI technologies and their application in the smart home to explore whether these technologies can be applied to smart furniture and address consumer expectations of the smart home.

3.1 Primary Research

The choice of primary data collection was in the form of questionnaires, which enables more findings in a limited time than interviews, to find general patterns and trends. Due to resource constraints the questionnaires were distributed randomly so that targets of all ages were surveyed. However, since groups are more likely to be concerned with smart furniture and represent its main consumer base, the target population to investigate is young people around 25 years old and middle-aged people around 40 years old.

Most of the questions in the questionnaire are closed multiple choice questions, there was additionally an 'other' option to provide alternative options for respondents. In addition, as well as collecting data on the main issues and for the future new smart home technologies that consumers want. There is also an open-ended question in the questionnaire that can help get a more subjective answers which ensures validity in the researcher as to why some consumers are choosing to use smart furniture. The first two questions collected information on the age and occupation of the respondents, the third and fourth questions asked about their use of smart homes, the fifth, sixth, and seventh questions asked about their attitudes towards smart homes, and the eighth and ninth questions asked about their attitudes and views on the future of smart homes.

The full questionnaire can be found in the appendix.

To ensure that the collected data could be effectively interpreted, a series of data processing and analysis steps were carried out. Firstly, some invalid questionnaires were deleted. For example, if the filling time is too short or the options are highly repetitive, it will be considered an invalid questionnaire. Then the percentage of each multi-choice question was analysed and pie charts or bar charts were made, which can make the data presentation more intuitive. Then the relationship between the advantages and problems of smart furniture and consumers' willingness to buy were analysed.

3.2 Secondary Research

Secondary sources were collected through Google Scholar Literature and other authoritative websites, and a reading log was made, as well as finding out whether the authors were authoritative, whether the content of the literature was helpful to the research, and whether the articles were published in recent years. The researcher ensured that the literature was credible, current and accurate.I will use the CRAAP rule to analyze the reliability of the paper. The main focus of the paper should be related to smart homes and artificial intelligence. Only articles within 10 years will be selected. The paper needs to be published in influential journals with a certain number of citations to demonstrate its authority, and the author needs to have a certain level of authority in the relevant field.

4. Results & Discussion

4.1 Results

The questionnaire revolves around the application of artificial intelligence in smart home, collected feedback from 75 participants, and investigated the situation related to smart home from various aspects, which is analysed as follows:

Basic information on survey respondents

Distribution by age

Under 18 years old accounted for 25.33%, 18 - 25 years

old accounted for 21.33%, 36 - 45 years old accounted for 21.33%, 46 - 55 years old accounted for 26.67%, the distribution of each age group is relatively even, and 55 years old and above only accounted for 1.33%. This shows that young people and middle-aged people have a high degree of participation in this survey, and these two groups are also the main groups that the questionnaire wants to understand.

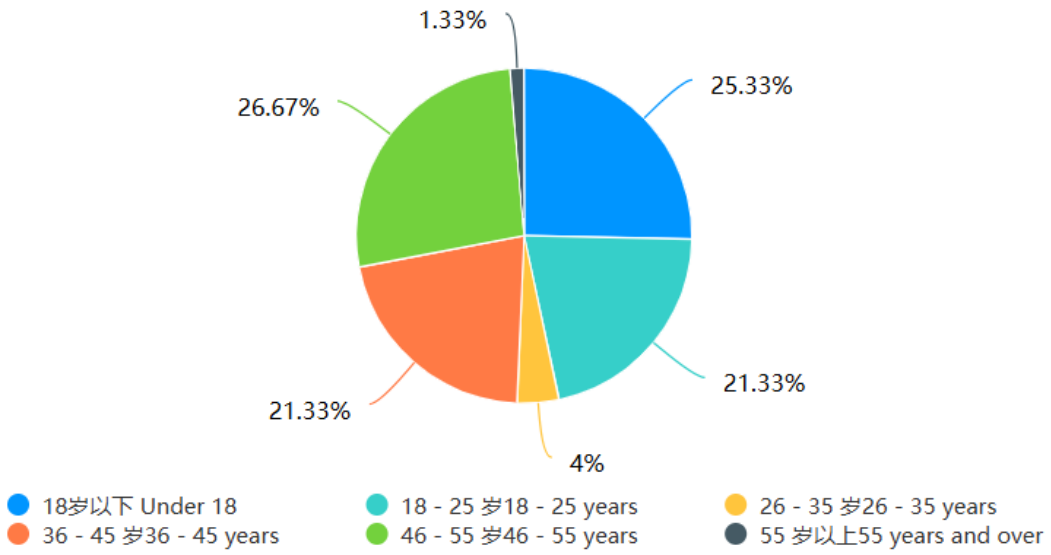

Fig 1. Age Distribution

Distribution by occupation

In terms of occupation, civil servants/careers accounted for 41.33%, which are the most, freelancers for 18.67%, employees of enterprises for 12 per cent, self-employed persons for 9.33% and 'others' for 18.67%. Except for employees of public institutions, the other groups are relatively even.

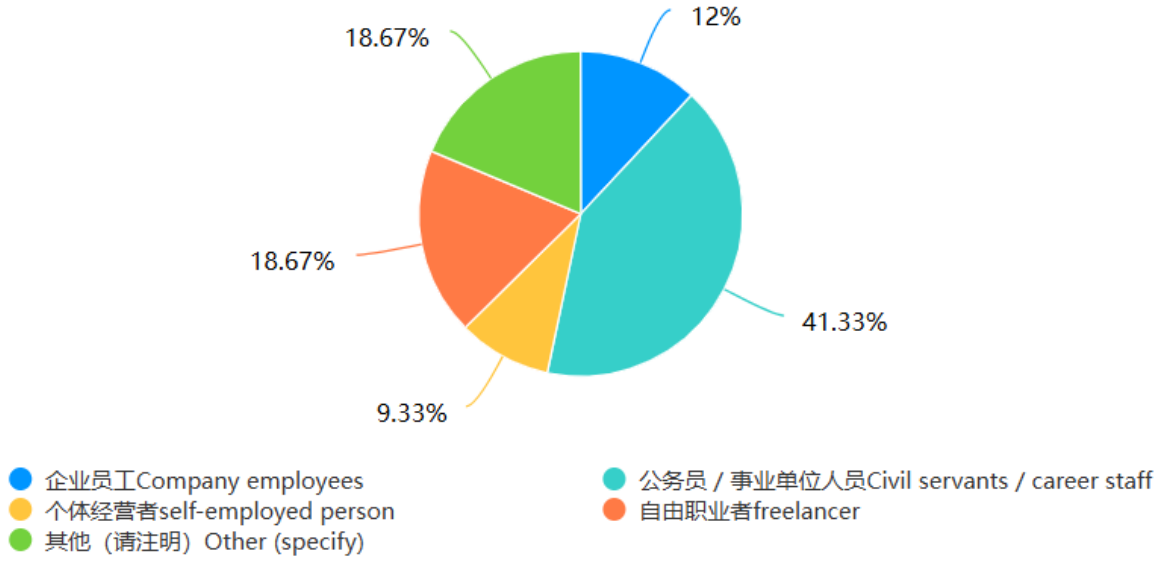

Fig.2 Occupation Distribution

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Smart Home Usage Status

89.33% of the respondents use smart home products at home, including 17.33% of households with most of the appliances being smart and 72% of households with some smart appliances, only 4% have plans to purchase smart home appliances and 6.67% have no plans to purchase smart home appliances. Indicating that smart home products have a high market penetration rate.

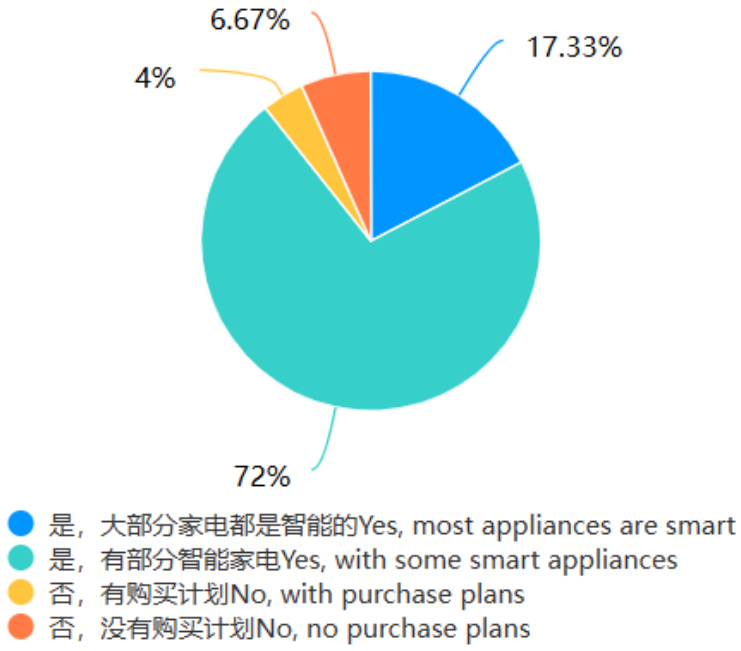

Fig. 3 % of smart appliances

80% of people understand and buy smart home through e-commerce platform, 77.33% of people understand through social media, these two channels are the main channels for people to understand smart home products, in addition, 56% of people understand through offline physical shops, 44% through friends' recommendation. Showing that online channels play a significant role in the promotion of smart home products.

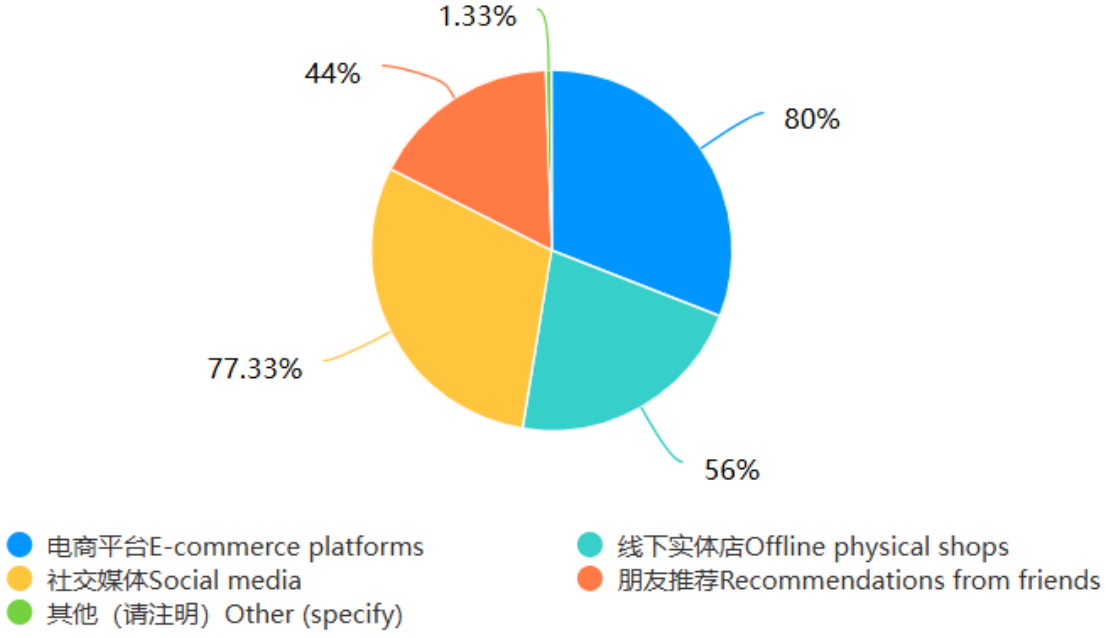

Fig.4 Where to learn about smart homes

Among the common functions of smart home products, voice control and remote control are the most popular among users, with 70.67% and 65.33% choosing these two functions respectively, and timer setting, intelligent scene linkage, and auto-sensing are also used by a lot of users, with 61.33%, 48%, and 46.67% choosing these functions respectively. This reflects that the convenient and quick control function is an important demand for users to use smart home products.

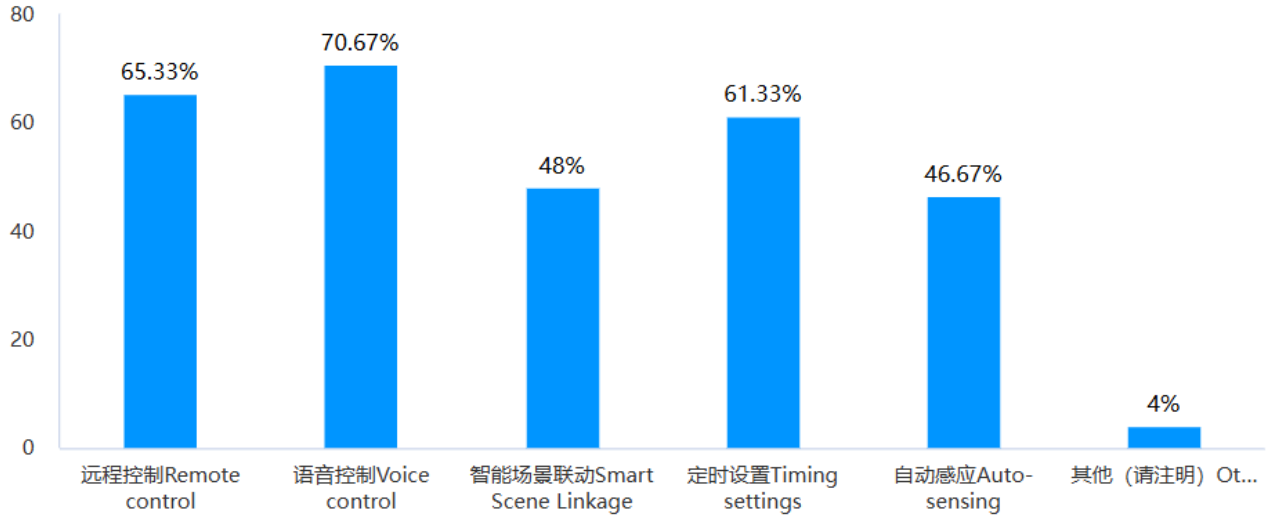

Fig.5 Popularity of different smart home features

80% of the respondents chose smart home products to improve the convenience of life, 62.67% of the respondents mentioned the pursuit of a sense of technology and a sense of freshness, 57.33% for energy saving and environmental protection, 45.33% to improve home security. It is easy to see that smart home can indeed make life more convenience.

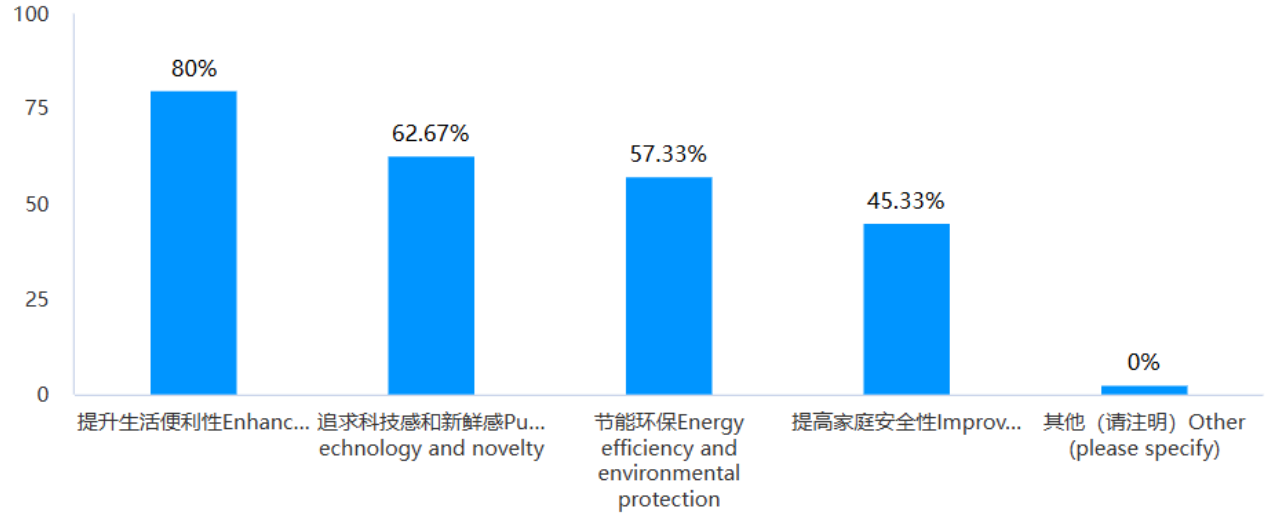

Fig.6 Reasons to use a smart home

Existing problems and future expectations

The use of smart home products faces many major problems. Among them, the poor compatibility between different brands of products is more prominent, 56% of the users feedback that this problem exists; poor product stability can not be ignored, 50.67% of the users believe that the product is prone to failure; the operation of the complexity, not easy to get started is also a major problem,

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46.67% of the users feel this way; the price is too high is also one of the factors affecting the user experience, 38.67% of users feel that the pricing of smart home products is too high; in addition, 40% of users are also worried about privacy and security issues. 38.67% of users think that the pricing of smart home products is on the high side; in addition, 40% of users are worried about privacy and security issues.

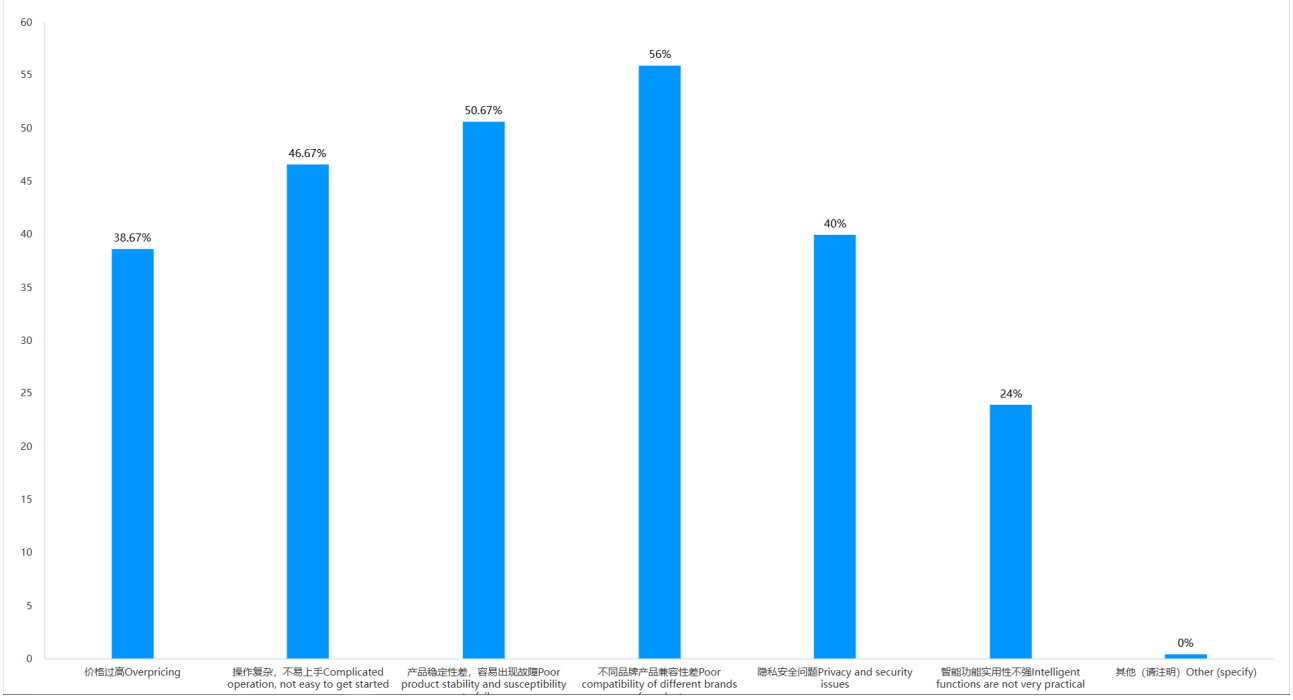

Fig 7. Existing Problems of Smart Home

In terms of expectations for future smart home product features, users have the strongest demand for personalised smart scenes, with 77.33% of users looking forward to this feature. At the same time, a considerable number of users want to add other functions, including the deep integration with community services, which accounted for 69.33% of users supporting this function; more powerful intelligent security functions are also of great concern, with 70.67% of users wanting to have them; more accurate health monitoring functions also gained the favour of 61.33% of users; and in addition, 49.33% of users expect that smart home products can achieve intelligent interconnection with vehicles.

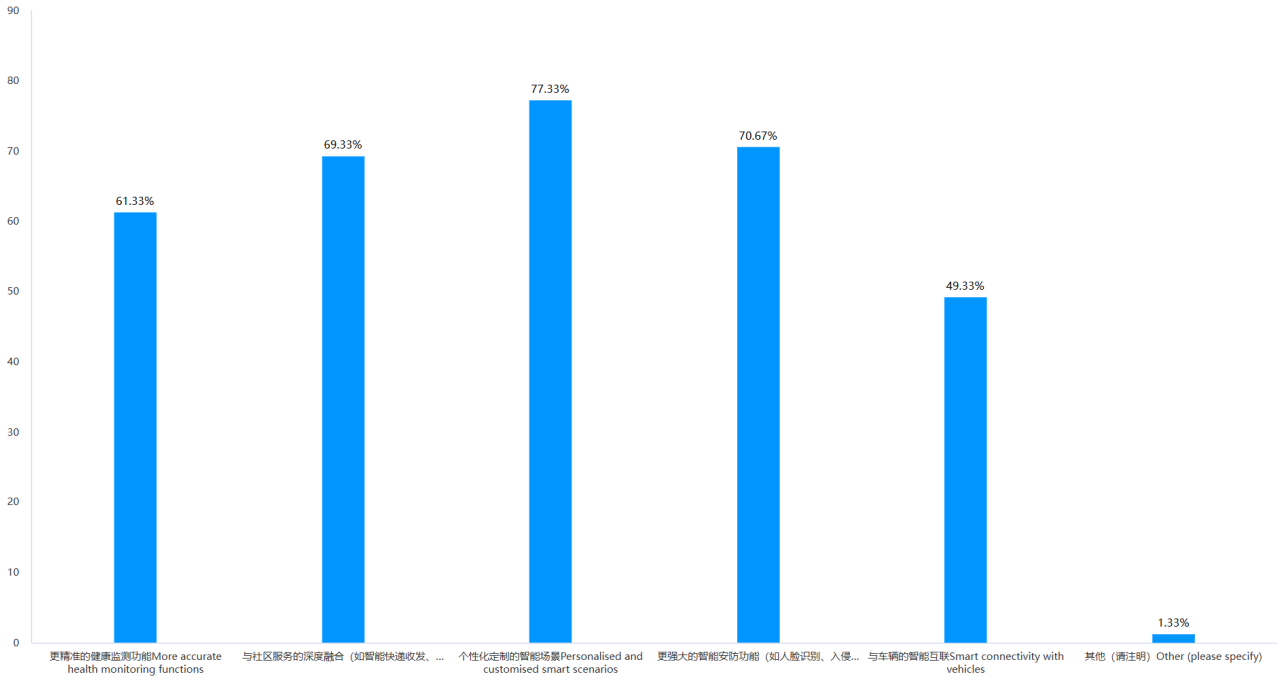

Fig.8 New Smart Home Features Consumers Want

Summary

Overall, the market acceptance of smart home products is high, and most consumers also have high expectations for their development. Although smart homes already have some popular features, they still face problems such as compatibility, stability and price. In the future, improving product ease of use and safety, and strengthening functional innovation and personalisation will help the smart home market develop further.

When examining the relationship between consumer expectations and current smart home features, the results show that while smart home products have achieved significant market penetration, there is still a considerable gap between consumer expectations and currently available products. For example, 89.33 per cent of respondents use smart home products, and 17.33 per cent have smart features enabled on most of their appliances. However, 56 per cent of users reported poor compatibility between different brands, and 50.67 per cent mentioned issues with product stability. This suggests that while smart home technology is widely adopted, user experience is often hampered by technical limitations and interoperability issues.

Among the issues raised by clients, more robust health monitoring functionality has progressed somewhat with the systems mentioned in 'Human Resource Dilemma and Intelligent Aging Options in China's Elderly Services'. As well as the more advanced voice control system that the customer wants, there is also a mention of a new future-proof system that can fulfil certain customer needs in 'Intelligent voice interaction will be the next gateway to the smart home'. The customer's needs. However, the compatibility, stability and complexity of the product still need to be improved. In the future, by improving AI algorithms, setting industry standards, and enhancing data privacy protection measures, smart home systems are expected to become more personalised, secure, and connected, thus providing users with a better living experience.

3.2 Discussion

Interpretation of the Results and Comparison to the Literature Review

According to the survey, smart home devices are now widely used, with 89% of respondents reporting adoption. Users are motivated mainly by the convenience and modern experience these technologies provide. At the same time, problems with device compatibility and unstable performance are among the most common drawbacks, reported by 56% and 50% of users respectively. There is also significant demand for more personalized automation (77.33%) and better data security. These findings help identify key areas where AI can add value—such as enhancing cross-brand compatibility, enabling systems that predict and prevent failures, and strengthening privacy protection through localized data processing.

Nowadays, smart home products have become quite popular, with 89% of the respondents in a survey indicating that they are using some type of smart home device. The

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main motivation for users to choose these products is to pursue a more convenient life and experience the new lifestyle brought by technology. This indicates that consumers view smart homes more as an improvement in the quality of life rather than merely for energy conservation or environmental protection.

With the maturation of the industrial chain and the continuous iteration of technology, the prices of smart home devices have gradually become reasonable, making them more affordable for an increasing number of people. Relevant research also shows that smart home devices have expanded from early niche applications to the mass market. The main driving force behind this trend is people's desire to upgrade their lifestyles rather than functional necessity.

Although there are still some challenges at present - as Huang and Huang (2018) pointed out, the high cost of building a unified ecosystem and the space occupied by control devices - technological progress is bringing new solutions. For example, control schemes based on low-cost AI training and more powerful and smaller processors can help alleviate the difficulties in current system deployment and further promote the wide application and popularization of smart home technology.

Similarly, product stability remains a significant concern, as highlighted by Zhang and Zhang (2023) in their research on smart homes for older adults. They stress that devices such as health monitors must operate reliably under real conditions and manage exceptions effectively—a capability still limited by current technology. This aligns with our survey findings, in which 50% of users reported dissatisfaction due to unstable device performance.

Compatibility is another major obstacle, noted by 56% of participants. The lack of unified industry standards leads to interoperability issues between brands, which in turn amplifies perceived instability and elevates costs. Additionally, 40% of users are concerned about privacy and security, while 38% consider smart home products too expensive for the value they provide.

These challenges are further evidenced in systems like the Arduino UNO-based storage and disinfection device developed by Gu et al. Although innovative and customizable, the system's limited functionality and potential safety risks—including electrical failures and cyber vulnerabilities—highlight broader industry hurdles.

The agreement between our data and existing studies confirms that these problems are widespread. AI technologies offer promising pathways toward solutions: adaptive protocols could improve cross-brand compatibility, machine learning may increase stability through predictive maintenance, and techniques such as federated learning could enhance data privacy by processing information locally. AI-driven optimizations could also help reduce costs over time.

Therefore, advancing smart home adoption will depend on creating more stable, secure, and cost-effective systems—goals that increasingly align with AI's evolving capabilities

On the other hand, these results offer a slightly different perspective from the optimistic view held by Ge and Li (2018), who saw voice control and smart speakers as the dominant future of the smart home market. Our survey reveals concrete user preferences: 77.33% of participants want more personalized smart scenarios, 70.67% still call for better use of voice control, and 69.33% prefer deeper integration with community services.

This indicates that although voice control remains relevant, it is not the only feature users care about. Instead, there is growing interest in more sophisticated and interconnected functions. One reason may be that the smart home industry has passed the early phase of excitement around single features like voice command. Now, users increasingly see voice interaction as a standard offering—a basic expectation rather than an innovation.

Another practical consideration is that voice control does not work perfectly in every situation. Background noise, such as a running television or other conversations, can make voice commands unreliable or awkward to use. This might help explain the stronger interest in personalized automation (77.33%) and integrated services—users want systems that anticipate their needs and minimize manual commands. For example, people may prefer that their lights, temperature, and music adjust automatically when they arrive home, rather than having to issue multiple verbal instructions.

In summary, while voice control continues to play an important role in smart homes, users are placing greater emphasis on personalized, automated, and seamlessly connected experiences. These findings suggest that the next generation of smart home systems should focus not only on refining voice interfaces, but more importantly, on building integrated ecosystems that support intelligent, context-aware automation across multiple devices and services.

4. Conclusion

In recent years, artificial intelligence and Internet of Things (IoT) technologies have developed rapidly, and smart home products have widely entered daily life, gradually becoming an important part of modern families. Through this analysis of user habits and needs, we have found that the penetration rate of smart home devices is already quite high, and most respondents have used at least one type of smart product. In terms of adoption motivation, users initially mainly considered the pursuit of convenience in life and the experience of technological novelty. However, as the usage time increases, they are

increasingly concerned about the compatibility between devices of different brands, the long-term stability of the system, data privacy and security, as well as the price rationality of the products.

A notable shift is that while traditional interaction methods such as voice control remain common, an increasing number of users are beginning to focus on more advanced features, such as customizable scene linkage and the integration of smart home systems with community public services. This change indicates that people are no longer satisfied with single, fragmented functions but rather aspire to build a strong, highly coordinated smart living ecosystem. This also suggests that the industry will move towards a scenario-based and ecosystem-oriented direction in the future.

When discussing the development path of smart homes, artificial intelligence has undoubtedly become a key technology for enhancing product usability, widely applied in areas such as automated control, voice recognition, behavior prediction, and energy management. However, this study further proposes that the significance of AI is not limited to these aspects - it should also focus on addressing the deeper issues that still exist, such as the difficulty in interconnecting devices, unstable system operation, high costs, and data security. These are not only challenges repeatedly pointed out by the academic community, but this study also finds that users are generating new expectations, namely that intelligent systems should have self-adaptability, predictive capabilities, and more comprehensive privacy protection mechanisms.

From a technical implementation perspective, various artificial intelligence methods can drive the development of this field. For instance, learning systems that adopt adaptive protocols can break down the interoperability barriers among products of different brands; predictive maintenance, leveraging big data analysis capabilities, can diagnose equipment failures in advance and enhance reliability; and the application of technologies such as differential privacy and federated learning can optimize models and perform inferences without collecting users' original data, significantly enhancing privacy protection levels. These AI-centered solutions not only offer practical improvement paths for existing issues but also provide crucial support for the construction of the next-generation smart home systems.

Of course, it must be pointed out that this study also has some limitations. The sample size of the survey is limited (a total of 75 people), which may affect the statistical significance and the validity of the results' generalization. The age structure of the sample is also unbalanced, with a relatively low proportion of people over 55 years old, making it difficult to fully reflect the real needs of elderly users. In addition, although the questionnaire survey method is efficient, the data is mainly obtained through self-reporting, which is prone to interference from subjective impressions and social desirability bias.

In subsequent research, the scale and diversity of the survey sample can be further expanded to cover a wider range of age groups, regional backgrounds, and user groups with different usage experiences, thereby enhancing the representativeness of the conclusions. At the same time, qualitative methods such as in-depth interviews, focus groups, or case study analysis can be introduced to gain more in-depth and detailed insights. On the technical front, the practical application effects of emerging technologies such as federated learning, edge computing, and blockchain in smart homes can also be further explored, especially in terms of specific performance in aspects like real-time system response, energy consumption control, privacy protection, and user experience.

Despite the above limitations, this study still provides a valuable reference for understanding consumers' attitudes and expectations towards smart homes. It not only confirms several issues pointed out in existing literature but also clearly reflects that user demands are shifting from basic functions to more personalized, integrated and secure overall solutions. In the future, the development of smart homes should not only focus on technological convenience but also leverage artificial intelligence to achieve deeper levels of intelligence, contextualization and humanization, in order to respond to users' continuously evolving expectations.

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