

Green Intelligent Homes: A Perspective on the Future of Smart Homes and Their Implications

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Abstract: The smart home technology market is witnessing rapid growth due to the advent of more advanced, intuitive, and affordable solutions. As the adoption of these technologies becomes more prevalent, there is a need for research to explore potential avenues for pervasive smart living. This study aims to review the available literature and industry studies, along with our own experiences in the field, to identify and discuss potential future research in the smart home. We observe that the future of the smart home will likely be focused on improving the user experience, with a greater emphasis on personalization, automation, and Artificial intelligence (AI)-driven technologies, leading to what we call the "Green Intelligent Home". Through this analysis, this study aims to offer insights into how the development of smart homes could shape society in the future and the potential implications of such a development. This study concludes by suggesting a framework for knowledge development in the smart home domain.

1 INTRODUCTION

The smart home has become an increasingly popular topic in recent years. For example, according to Dimensions¹, the number of studies about smart homes – publications with the term "smart homes" in their title and abstract – has increased from 908 publications in 2015 to 2,366 publications in 2020. This is mainly due to the proliferation of affordable and accessible smart home technologies. It has also seen significant growth in recent years, due to the development of technologies such as the Internet of Things (IoT), sensors, smart appliances, cloud computing, as well as digital assistants, and an increased understanding of smart home technology's potential impact on privacy and way of life. Smart home technology can be seen as an extension of building automation into the residential environment through the use of IoT technology. The network-connected devices, which are known as smart home devices or smart devices, are typically interconnected to a smartphone or tablet via technologies like Wi-Fi, Thread, or Bluetooth. A

typical smart home may include devices such as connected video doorbells, smart speakers, and electronic door locks (Bugeja et al., 2022). The home may refer to a single-family house, an apartment, or other type of living situation (Tannou et al., 2022). Meanwhile, the emergence of various IoT-based devices, such as those produced by global technology leaders such as Amazon, Google, and Samsung, has driven recent developments in smart homes.

According to Fortune Business Insights², the global smart home market is also expected to grow from \$99.89 billion in 2021 to \$380.52 billion in 2028. Also, according to Statista³, there will be around 375.3 million smart home devices in 2024. Smart homes are considered one of the critical enablers of the shift toward smart living. Smart living promises to increase the comfort, security, and energy efficiency of our daily lives through digitalization and the networking of smart devices. The popularity of smart homes is due in part to the many potential benefits that they offer.

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¹ <https://app.dimensions.ai> [Accessed on 01-March-2023].

² <https://www.fortunebusinessinsights.com/industry-reports/smart-home-market-101900> [Accessed on 01-March-2023].

³ <https://www.statista.com/forecasts/887613/number-of-smart-homes-in-the-smart-home-market-worldwide> [Accessed on 01-March-2023].

For example, smart homes can save energy by automatically adjusting lighting and heating and cooling settings based on user preferences. Some studies also discuss smart homes as one of the core elements of sustainability efforts due to their energy-efficiency-related benefits; in fact, multiple studies emphasize smart home technologies for achieving net-zero energy buildings (AlFaris et al., 2017). Smart homes can also provide increased security and safety by allowing users to remotely monitor their homes from anywhere in the world. They are also seen as a key enabler for personalized care and independent living for the elderly, disabled, or chronically ill (Basarir-Ozel et al., 2022). Additionally, smart home technology can make everyday tasks easier and more convenient for all users, such as by allowing them to control appliances with their voice or gestures. Hence, it is a valid assertion that smart home technology has improved the intelligence and interconnectedness of our conventional homes, thereby promoting the advancement of the concept of smart living.

Despite the growing interest in smart homes, the existing research has, to the best of our knowledge, not yet fully explored the potential futures of the smart home and how it is advancing the concept of smart living. This study seeks to fill this gap by reviewing the scientific literature in the field of smart homes, as well as industry studies and our own experiences from years of research in the smart home field. We identify four main characteristics for the smart home of the future, i.e., what we refer to as the "Green Intelligent Home". The research documented in this paper is relevant as it can help inform stakeholders in the smart home market and reveal opportunities and potential implications of this rapidly developing field, which is closely intertwined with personal life in our homes and most private spaces. The findings of this research can also be used to guide the development of the smart home market and create a more sustainable and efficient future.

2 BACKGROUND AND RELATED WORK

For decades, visions of smart homes with advanced technologies have been developed under various names such as "Intelligent Home", "Smart Home", "Interactive Home", and "Home of the Future" (Friedewald et al., 2005). However, these early versions of smart homes were largely limited to laboratory experiments and could only be controlled locally with limited user interaction (Bugeja et al., 2018). They were not typically integrated into the everyday

objects of the home and were not connected to the Internet in the widespread and pervasive way that current smart home technology is.

According to Aldrich (Aldrich, 2003), a smart home can be defined as "a residence equipped with computing and information technology, which anticipates and responds to the needs of the occupants, working to promote their comfort, convenience, security and entertainment through the management of technology within the home and connections to the world beyond". Balta-Ozkan et al. (Balta-Ozkan et al., 2013) define a smart home as a "residence equipped with a high-tech network, linking sensors and domestic devices, appliances, and features that can be remotely monitored, accessed or controlled, and provide services that respond to the needs of its inhabitants". These advanced user assistance systems help inhabitants fulfill different tasks and provide (intelligent) assistance. Bugeja et al. (Bugeja et al., 2022) describe a smart home as a residence that utilizes Internet-connected technologies to automate and manage the various appliances, devices, and utilities within the home. These technologies often harness AI techniques, such as machine learning, in their devices to increase their autonomy. The demand for improved comfort, safety, energy efficiency, and health, as well as advancements in economics, society, and technology, drive the smart home market and contribute to the expanding potential of these homes.

This expansion of the smart home is recognized in earlier works, such as Solaimani et al. (Solaimani et al., 2015) and Berry et al. (Berry et al., 2016), as a constantly evolving field with many possibilities. Solaimani et al. (Solaimani et al., 2015) suggest that the term "smart living" may be a more accurate description of the expanding technology as it extends beyond the traditional residential setting. Berry et al. (Berry et al., 2016) describe the smart home as a "fluid and unstable field of possibilities," emphasizing the potential for innovation and growth in various directions. With the smart home growing outside of the physical home and into outdoor and communal spaces, digitized bodies, and mobile devices, this industry has an expanding spectrum of goods and services in addition to the continuous growth of space itself. Additionally, differences can be seen across the market, from low-cost DIY solutions and off-the-shelf products to high-end, architecturally designed, fully integrated, and professionally installed homes. As such, the concept of the smart home is no longer just about convenience, safety, and peace of mind but also about smart living, with the home being wherever we are constantly in the service of whatever its human owners (users) want to do.

This shift towards putting individuals at the center has enabled the development of services that provide them with a maximum range of services, such as medical care, without requiring them to leave their homes. Some industry leaders argue that the current smart home is merely a connected home, where legacy devices are upgraded with intelligence, command, and control, but are still distant from providing truly intelligent services that can anticipate and respond to the needs of their inhabitants. An intelligent home that focuses on providing a personalized experience to its users is recognized as the next evolution of the smart home. As the boundaries of the smart home expand, so do the possibilities of what it can offer, including the provision of new services and the merging of the smart home with other domains such as healthcare, education, and entertainment.

As the smart home industry continues to expand, there is a growing need for research in this area. This includes exploring the usage of smart home technology in various settings, how it can be used to improve the lifestyle and environment of users, and how it can affect the wider society and economy. Additionally, research is needed to understand the implications of this technology in order to ensure that it is used responsibly and ethically. This understanding of the implications of smart home technology is vital for responsible smart home development.

3 POTENTIAL FUTURE SCENARIOS OF SMART HOMES

In order to investigate visions of the future smart home, we reviewed a variety of sources, including scientific literature, industry studies, consumer magazines, newspapers, and online forums and blogs. We also looked into actual technological products, particularly by examining the Consumer Electronics Show⁴, arguably the largest global technology tradeshow showcasing various smart home technologies.

We conducted a manual, thematic analysis of the extracted information. As a result of the thematic analysis, we identified four key characteristics (themes): autonomy, personalization, connectedness, and sustainability. These characteristics provide insights into the potential avenues for the future of the smart home and how it could revolutionize the way we live. We refer to a smart home that exhibits all the mentioned characteristics as the "Green Intelli-

⁴<https://www.ces.tech> [Accessed on 01-March-2023].

gent Home" (see Figure 1). The results of these investigations are presented in Section 3.1–3.4 and represent potential future scenarios for the smart home. We also remark that the future of the smart home is difficult to predict with certainty, as it is dependent on a number of factors, including technological advancements, consumer demand, and industry developments. Nonetheless, industry trends and technological progress suggest those characteristics that are likely to continue to evolve over the coming years.

3.1 Completely Autonomous Smart Homes

Smart homes of the future will be completely autonomous, able to run and manage themselves without any input from their human occupants. Employing AI and IoT technologies, these homes will be able to handle all of the mundane tasks of daily life, freeing up their occupants to pursue more interesting and enjoyable activities. Recently developed AI-powered robots that help pick up items around the house and act as personal assistants, for example, have already demonstrated a certain level of autonomy⁵. In the future, humans will not have to think or intervene like engineers, as they will not have to configure, update, integrate, reboot, or manage any part of a digitalized home. The home will require no input from humans. Partly, this may be possible through the use of self-sustainable sensors, which reduce maintenance requirements (Dong et al., 2021). Also, it may be possible by using brain waves as the smart home control mechanism, i.e., the Brain Computer Interface (BCI) (Bennett et al., 2017). BCI technology is still at an early stage, but there are already applications of it in smart homes, for example, for in-home monitoring of dementia care (Ienca et al., 2018).

Intelligent decision-making and control systems, based on machine learning, will be able to observe, learn, adapt, predict, and respond to the needs, lifestyles, and habits of occupants. Furthermore, these systems will be able to proactively determine the needs of occupants and provide services accordingly that are tailored to the individual occupants. Predictive systems that offload cognitive mundanities from everyday life by determining what tasks are likely to be done next and doing them on our behalf are developing rapidly (Dunne et al., 2021). Even security protection and privacy measures will be further strengthened by incorporating fully autonomous capabilities powered by machine learning, making it an

⁵<https://www.cnet.com/home/smart-home/samsung-ces-2021-robots-will-clean-your-house-and-pour-you-a-glass-of-wine> [Accessed on 01-March-2023].

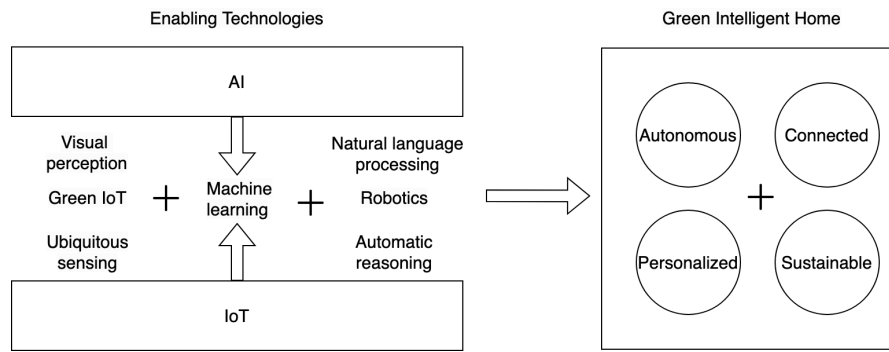


Figure 1: A conceptual representation of the Green Intelligent Home and the main technologies enabling it. This home combines IoT and AI to provide a completely autonomous, personalized, connected, and sustainable smart living environment for the occupants.

increasingly vital feature in the smart homes of the future. This enhanced convenience and comfort provided by autonomous smart homes has the potential to greatly improve the lives of their occupants.

3.2 Completely Personalized Smart Homes

Smart homes of the future will be able to provide their occupants with a completely personalized experience, tailored to their individual needs and preferences. Through the use of innovative technologies such as AI-based decision support systems, 3D sensors, Bluetooth beacons, and ultrasound signals, as well as non-invasive methods for monitoring human state and environmental parameters, smart homes will be able to adjust their temperature, lighting, and sound levels to suit the occupant's needs, as well as provide them with tailored entertainment, optimal security, and engaging informational content. The characteristics of this type of home that are intended to promote natural and meaningful interactions between the home and its occupants were already identified in the survey published by Meyer et al. (Meyer and Rakotonirainy, 2003) in 2003.

Moreover, smart homes of the future may support adjustments, perhaps through robotics, to the furniture layout to perfectly suit the occupant's needs and moods. The alteration of the living space can also be used to increase exposure to visual cues, helping the residents form new habits. Indeed, interventions that disrupt the environmental factors or cues may result in habit changes (Verplanken and Wood, 2006). By combining multiple input sources, smart systems will be able to better understand and implement individual preferences, sensing who enters and exits a room while changing the light, sounds, temperature, and safety features accordingly. Smart homes will also improve their ability to make context-aware decisions

for providing personalized services such as managing air quality and heating, as well as providing assistance with product finding and automated billing, with the aim of providing a much higher level of comfort, safety, and functionality. This may be achieved without relying on additional appliances or plugin features, as smart homes already have built-in technologies that support these functions⁶. An alternative to the smartphone, which is currently the main device used to communicate with smart homes, may be intelligent intuitive interfaces which are embedded in objects and the environment (Dunne et al., 2021). This would allow users to interact with their entire smart home, at least locally, in a more natural way without the need for a separate device in the future.

3.3 Completely Connected Smart Homes

Smart homes of the future will be completely connected, allowing for a range of communication and data-sharing capabilities, as well as services and environmental monitoring. All of these devices and appliances within a smart home can work together, communicating with each other, to create a truly connected home. With advancements in technology, it is anticipated that device and service interoperability will not be a pertinent issue, allowing for a seamless connection between devices, services, and the user. In line with this trend, a new royalty-free standard for smart home devices, known as Matter⁷, has been released recently with the goal of making all smart home devices interoperable.

⁶<https://www.cambridgeindependent.co.uk/business/smart-homes-will-soon-take-care-of-you-reports-idtechex-9286085> [Accessed on 01-March-2023].

⁷<https://csa-iot.org/all-solutions/matter> [Accessed on 01-March-2023].

Moreover, smart homes of the future will be better connected with their surrounding environments. For example, they will be able to communicate with smart cities to provide access to services such as public transportation, energy management, emergency response, and environmental monitoring. This will provide homeowners with an enhanced level of safety and convenience. Connectivity, more specifically extended networks that go beyond the boundaries of the physical home to smart gardens, smart driveways, and beyond smart neighbors, is possible with mesh networking technologies such as Amazon Sidewalk⁸ that increase the range of low-powered connected devices. It is also likely that interconnectivity between smart home devices and their users will be faster through the use of new standards such as Wi-Fi 7 and as 5G becomes more widespread. Additionally, data collected from smart homes can be used to improve local services, making life more comfortable for both inhabitants and visitors. The data collected from smart homes can also be used to analyze and predict patterns in order to better understand the relationships between people and their environment. Moreover, as machine learning algorithms continue to improve, the data collected from smart homes can be used to generate increasingly accurate predictions and recommendations that can further enhance the user experience. Furthermore, it is possible that the integration and cross-referencing of IoT data from various devices within an individual's home, office, and car across platforms within Web2 and Web3 will become increasingly prevalent⁹. This could lead to a truly integrated and personalized experience that adapts to the user's preferences and needs, both inside and outside the home.

3.4 Completely Sustainable Smart Homes

Smart homes of the future will be completely sustainable. With advances in technology, such as renewable energy sources, automated systems, and smart appliances, these homes can produce their own energy, reduce their energy consumption, and manage their waste. Focusing on sustainability, the University of Suffolk has recently unveiled a smart home that aims to produce as little carbon footprint as possible while still being a home that can be comfortably lived

⁸<https://www.aboutamazon.com/news/devices/introducing-amazon-sidewalk> [Accessed on 01-March-2023].

⁹<https://www.forbes.com/sites/forbestechcouncil/2022/06/24/15-tech-leaders-predict-the-next-big-trends-in-home-iot> [Accessed on 01-March-2023].

in¹⁰.

Future smart homes will be able to generate their own energy from renewable sources, such as solar, wind, and geothermal, to reduce their reliance on utilities, and potentially eliminate the need for an external power grid. Automated systems, like building-integrated photovoltaics and solar thermal panels, will be able to regulate the energy production and needs of the home. Smart appliances will be able to intelligently adjust their energy use according to the energy needs of the home. This may be possible as the smart home devices will be better equipped to respond to signals received from the energy provider. This type of home will leverage also low-power consuming IoT, also known as Green IoT (Thilakarathne et al., 2022), to help mitigate the climate crisis in the forthcoming years. Additionally, novel self-powered human-machine interfaces (Dong et al., 2021) capable of producing electrical signals upon external stimuli, such as body motion, may be integrated. Energy harvesting from nearby connected devices, for example, through radio frequency signals, may lead to potentially battery-free solutions in the future. Finally, smart homes will also be able to produce and recycle their own waste, eliminating the need to transport it to external waste disposal sites. Alternatively, it may be possible to have autonomous drones or vessels automatically collect and dispose of garbage and debris in order to keep the surrounding area clean¹¹.

4 POTENTIAL CONCERNS AND IMPLICATIONS

Smart homes greatly impact our lives, work, and social interactions. However, it is crucial to address potential societal concerns and implications. Table 1 links each Green Intelligent Home characteristic to relevant concerns.

4.1 Privacy and Security

As smart home technology becomes increasingly connected to external networks and more automated, it also becomes more vulnerable to cyber attacks, raising concerns about the potential for misuse or abuse of personal data (Iten et al., 2021). For instance, if an adversary gains access to certain smart home devices

¹⁰<https://www.eadt.co.uk/news/23170971.suffolk-unveils-home-future-martlesham-bt-park> [Accessed on 01-March-2023].

¹¹<https://oceanbuilders.com/blog/autonomous-surface-vessel> [Accessed on 01-March-2023].

Table 1: Summary of the characteristics of the Green Intelligent Home alongside the main concern being affected by each. The symbol: ● indicates that the concern impacts the characteristic; ◐ indicates that the concern may impact the characteristic; and ○ indicates that the concern is unlikely to impact the characteristic.

Smart home characteristic	Privacy and security	Energy consumption	Manipulation and inequality risks	Lack of self-sufficiency
Autonomous	◐	◐	◐	●
Personalized	●	○	◐	◐
Connected	◐	◐	●	○
Sustainable	○	●	○	○

or services, they can potentially track the residents' location, activities, and whether they are home or not. Smart home devices may also collect sensitive data, such as health-related data collected from biosensors, making them vulnerable to breaches if proper security measures are not in place. Moreover, as the number of connected devices in a household increases, the attack surface also grows, making it more challenging to secure the home network. The increasing automation and connectivity of smart home technology make it increasingly challenging to protect ourselves and our data from potential threats. Smart home technology could be used for surveillance or intelligence gathering without the residents' knowledge, like with smart speakers that always tend to listen for voice commands. Such uses of technology could have consequences for civil liberties and freedom of speech and expression. These issues could become even more pressing as devices become integrated with sophisticated language models like ChatGPT. The seriousness and extent of smart home attacks can be understood, for example, in the context of a US household, which is expected to have an average of 20 connected devices by 2025¹².

Companies can assure customers that their data is safe by offering reduced insurance premiums, subscription rates, or other forms of sponsorship. There are also existing standards and regulations, such as ETSI EN 303 645, the Security Evaluation Standard for IoT Platforms, ISO/IEC 27402, and others that focus on the security and privacy of consumer IoT devices. Another potential solution to these concerns is the use of the Artificial Intelligence of Things (AIoT), which represents the convergence of AI and IoT (Tan et al., 2022). By embedding AI directly into the devices that we use daily, the AIoT offers a new way to deliver AI that can help protect data and ensure that it is only shared when necessary, thereby enhancing both security and privacy. This evolution may also lead to smart home devices with autoimmunity, allowing them to automatically prevent and contain certain security attack vectors. To prevent misuse or abuse

¹²<https://www.parksassociates.com/blog/article/pr-06152020> [Accessed on 01-March-2023].

of AIoT technology, responsible smart home development and the implementation of measures to ensure data protection and privacy are crucial, including the use of AI to monitor and secure smart home systems and devices and the implementation of strict data privacy policies and practices.

4.2 Energy Consumption

Additionally, even though smart homes could help reduce energy consumption by automating energy-saving tasks, they could also lead to an increase in energy consumption as more devices are connected and require more power to run. This could lead to a strain on the energy grid, resulting in power outages and other issues. It could also result in higher electricity bills, longer wait times for repairs, and an increased risk of blackouts. This scenario could then lead to a decrease in the quality of life for many people, particularly those with low income, as the cost of energy becomes a greater burden on their budget. Additionally, if energy costs continue to rise due to increasing demand or the limited availability of fossil-based fuels, they could have an adverse impact on the environment, leading to higher levels of air pollution and a greater risk of global climate change.

The incorporation of AIoT in smart home technology allows for the transition from an "always listening" version to an "always ready" version. This means that sensors will only be in use when needed, reducing the continuous demand for electricity. This may also reduce the effect known as standby power, where connected devices continue to use electricity when they are not in use. Another benefit of the AIoT is that it enables more efficient data transmission through the compression of large amounts of data into smaller packets, requiring less energy for sending. These features enhance the functionality of smart homes and also decrease the energy needed for their operation. The use of low-power protocols such as Thread improves energy efficiency even further. Therefore, responsible smart home development must prioritize energy efficiency in order to ensure the sustainable and environmentally-conscious use of this

technology. By implementing AIoT, smart homes can effectively reduce their energy consumption through more efficient energy usage and data transmission.

4.3 Manipulation of People and Inequality Risks

There are concerns that smart home technology could be used as a vector to manipulate people's behavior by sending targeted marketing messages or other incentives to users in order to encourage certain behaviors or target certain goals, such as political or commercial objectives. For example, a refrigerator LCD display could be used as an advertising platform by technology providers. This could be used to incentivize the residents to buy certain products or even sway their opinions on political or social issues. It can also occur more subtly in the form of customer reward schemes or loyalty programs that offer residents discounts on, for example, their home insurance if they enroll in such schemes. This data can be used to create profiles of individuals that could then be sold to third parties without the user's knowledge or consent, further adding to the potential for manipulation and exploitation. Additionally, there is a risk of increasing inequality as the technology becomes more expensive and out of reach for some people, potentially widening the gap of inequality between those who can afford smart home technology and those who cannot. The high cost (e.g., initial price, subscription cost) for buying and using smart homes was identified in a recent study by Basarir-Ozel et al. (Basarir-Ozel et al., 2022) as the most prevalent inhibitor of their adoption. This means that those with access to this technology may be able to enjoy a more comfortable lifestyle than those without, creating a divide in society.

It is suggested that smart home technology be subject to ethical and responsible regulations, given that the regulatory landscape for smart home technology and IoT is still in its early stages and varies across different countries and regions. In this regard, the European Union's General Data Protection Regulation serves as an example of how laws and regulations can be used to ensure that companies are transparent in their use of data collected by IoT devices and smart home technology. Additionally, industry best practices should be established to ensure that companies are using the technology responsibly and ethically so as not to coerce, deceive, or manipulate people. A framework that comprises measures to enhance responsible smart home development could be enacted to ensure that smart home technology is used ethically and transparently and does not contribute to the

widening of existing inequalities or the creation of new ones.

4.4 Lack of Self-sufficiency

The increased reliance on technology, particularly the further the smart home is advancing to become more autonomous, could lead to a decrease in self-sufficiency. This is as people, in general, become increasingly dependent on technology to do their tasks for them. This could lead to a decrease in problem-solving skills, critical thinking, and creativity as people become less able to think for themselves without relying on their devices. This could leave people vulnerable in the event of a power outage, cyber attack, or malfunctioning technology. A practical example of this in the context of the smart home could be a user who has forgotten how to manually adjust the thermostat settings due to habituation, leading to a sense of learned helplessness regarding their capacity to control the thermostat. To mitigate this effect, the user may have to take the time and effort to re-learn how to adjust the thermostat manually as opposed to relying on the device. The lack of self-sufficiency could also lead to increased feelings of helplessness and isolation as people become unable to do even simple tasks without the help of their technology (Sriram et al., 2020). Increased dependence on technology could lead to a decrease in the ability to be independent, which could have a negative impact on our society. It can also lead to some consumers, particularly those who are unprepared for technology, developing a psychological state of mind characterized by anxiety (Mani and Chouk, 2018).

To reduce the risk of decreased self-sufficiency, it is suggested to incorporate education and training into the use of smart home technology. This could include actively teaching users how to perform basic tasks manually, so they do not become completely reliant on the technology. Additionally, it is recommended to encourage users to think critically and creatively when using their devices rather than simply relying on technology to do the work for them. Furthermore, it is essential to provide users with the necessary resources to troubleshoot and fix their devices, such as information and assistance from the AI or online communities, so they can become more self-sufficient, especially in the event of malfunctioning technology.

5 DISCUSSION AND CONCLUSION

The smart home is a rapidly evolving technology that has the potential to revolutionize the way we live. In this study, we provided an account of how smart homes can shape society in the future by describing four scenarios that are emerging in the smart home market and leading to what we coin the "Green Intelligent Home", and the potential concerns and implications that they could bring. These four scenarios include increasing autonomy, personalization, connectivity, and sustainability in the smart home market.

One of the limitations of this study is the lack of empirical data to support our claims. Future research could address this by conducting large-scale surveys, case studies, and experiments to validate our hypotheses. Additionally, the potential benefits and risks associated with the scenarios described in this study could change as technology evolves. Nonetheless, this study contributes to the ongoing discourse on the future of smart homes and the potential implications of their widespread adoption.

As we move into the future, responsible and ethical use of technology is crucial to maximize its benefits. A shared framework for responsible smart home development among users, governments, and the market is needed to address potential negative implications, including privacy concerns and abuse, as well as legal and ethical considerations. Further research can enhance our understanding of smart home implications and inform future decisions regarding the technology.

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