Research on the Development of Smart Home Based on Multi-Perspectives

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Abstract. With the continuous growth of China's emerging industries, the digital life of Chinese has ushered in a new era, and smart home has a huge market and user value. In order to provide a reference for the theoretical research of smart home, and help the application and development of the important concept of "smart +" was first proposed in the 2019 government work report. Through systematic review of domestic and foreign literature on smart home, the reasons for the rapid development are summarized from the functional and social technology perspective. The challenges faced in the development are summarized from the user’s point of view. The trend of smart home development is summarized from the perspective of industry and society.

1. Introduction
In an information society, while changing contemporary people's modern lifestyles and generational habits, it also poses corresponding challenges to traditional home living spaces. Nowadays people are yearning for the advanced nature and intelligent existence of family life, and they are increasingly favouring the use of home smart devices. According to the "IDC China Smart Home Device Market Quarterly Tracking Report", shipments in China's smart home market reached 150 million units in 2018, up to 35.9% year-over-year growth.[1]

The paper performs the advanced retrieval of academic journals on CNKI (China National Knowledge Infrastructure). The subject of the search criteria is smart home. The source categories are SCI and EI source journals, core journals, CSSCI, CSCD, a total of 611 journals, which were published from June 1, 2002 to December 1, 2019. The co-occurrence analysis of 634 journal keywords was performed through the visualization software Cite Space. The top four keywords after the smart home was removed were: Internet of Things (86 times), Zigbee (54 times), and Remote control (29 times), Wireless sensor network (20 times). Comprehensively comparing and analysing the research topics of 634 journals, it is found that most of the journals are related to the technical field involved in smart home, while there are relatively few journals related to the development of smart home. In view of this, the paper will elaborate on the concepts and definitions, opportunities and challenges of smart home from the perspectives of academic research, user use, industry development, and social impact.

2. Definition of Smart Home
Since the concept of smart home was proposed in the 1990s, its definition has been supplemented with the development of related technologies. According to Le et al., smart home should have
several foundational characteristics: robotization, multi-function, adaptability, interactivity, and high efficiency.[2] Sumaiti and Ding also point out that the goals of smart home can be achieved by identifying relevant human life activities and increasing degree of automation in the home environment, or by using remote home control to support home comfort and improve home safety and promote energy consumption management.[3][4] The general definition of smart home in all walks of life in China is to use automatic control technology, integrated wiring technology and network communication technology, etc. to effectively achieve environmental protection, energy saving and safe and comfortable living environment. The main application scenarios of smart home in China include home security, child care, whole house control, energy management, etc.

3. Reasons for The Development of Smart Home

The development of smart home has experienced four generations. The first generation, which was mainly based on coaxial lines and two core wires for home networking, realized local control of home device. The second generation, which is mainly based on RS–485 lines and partly based on IP technology for home networking, realized smart security for the home. The third generation has realized the centralization of home intelligent control. Based on the IOT technology, the fourth generation has realized customized and personalized services for home functions based on user needs.

Why are smart homes thriving in research and industrial development? The paper summarizes its reasons into two types of perspectives: functional perspectives and socio-technical perspectives. The former perspective regards smart home as an effective way to manage daily needs through technology. The latter perspective regards the application of smart home as the next wave of efficient development in the electrification and digitization of home daily life.

3.1 Functional Perspective

Allam believes that the smart home is to build a better quality of life by deploying fully automatic control equipment and providing auxiliary support.[5] User-centered researches also explicitly emphasize the enhancement of available services rather than the furnishment of novel services. "The purpose of technology application is not to substitute the family experience we already comfort today... [but] to stand by or make up the experience in a fresh way."[6] Balta-Ozkan et al. divided smart home services into several classifications as supporting for lifestyle, management of energy and security. [7] Smart home can remotely control specific devices, enhance security through simulated occupancy when the home is idle, etc. and even include the elderly and other families currently marginalized in the information society into smart home to help overcome the digital divide.[8] These correspond broadly to the perceived needs of users to improve home comfort, convenience, safety and entertainment.[9] Smart home also provide low-cost home energy transformation technology solutions, [10] which can enable homes to make anmore extensive conversion to a low-carbon and environmentally-friendly future. Improving home security is also of obvious value to users.[11] Home security is more considered to be a family need for future development.

3.2 Socio-technical Perspective

Axsen et al. Believe that the use of smart home technology will affect social construction and iterative negotiation, rather than the inevitable result of functional gains.[12] The Socio-technical perspective regards that as the up-to-date event in the synergy among technology and technology. The vision of technology developers for smart living has enriched this socio-technical explanation. Park et al. sketched working prototypes of smart appliances, smart switch sockets, smart shade doors and windows, etc., and provide a corresponding wide range of services, including memory storage, situational reminders, automatic identification, associative exploration, and device association. [13] Taylor et al. emphasized the latent capacity of almost all surfaces and boundaries to turn into digital and intelligent displays in the "surface ecology" of user interaction.[14] Hussain et al. pointed out that even in the health field, smart home have more explicit monitoring functions for family members, and smart technology must be "seamlessly embedded into our daily lives."[15] What
sets the socio-technical perspective apart is that this technological development has inevitably co-evolved with wider-ranging and longer-term social changes, which may include mediate and unintended consequences. Social practices in family daily life can be combined or arranged in new styles.[16]and differentiation related to key family housework and leisure will be strengthened.[17]Smart home technology will also dramatically change the understanding and experience of households and family life.[18]

4. Challenge Analysis of Smart Home
Before the widespread commercialization of smart home becomes a reality, many challenges such as R&D and testing need to be overcome. The key technologies of smart home mainly include sensor technology that senses the dynamic information of objects, communication technology and network converged technology to realize information transfer, intelligent technology to realize information processing and information security technology. The technical literature on mainstream smart home and user research reveals that smart home development and design should be user-centered.

Edwards et al. emphasized various fields of the responsibility challenge: conflicts and checkout errors in smart home technology components; smart home cannot be managed and maintained through self-healing systems; sensor data presents a large amount of ambiguity that can lead to inaccurate inferences and decisions.[19]As a multi-type heterogeneous converged network, smart home not only has the same security problems as the Internet, sensor networks, mobile communication networks, etc., but also has complex problems such as privacy protection, access control, routing security technology, data storage and management.

Some studies also emphasize the importance of responding to user operation requests and adapting to environmental changes in smart home. Bernheim et al. believed that the multi-dimensional complexity, latent flexibility and unsatisfactory manageability of smart home offset the users' longing for smart homes.[20] The complex installation, commissioning and use process of smart home system will restrict the transformation from R&D products to consumer products. And between different cultures and even between families, different users need different smart home application design solutions. Jeong et al. revealed a clear difference in understanding and demand for control among smart home users in the United States and South Korea.[21] In addition to the reasonable control of home device, users expect their home life to be managed effectively. Therefore, the smart home also needs to meet the intelligent needs of users to deal with messy and different in daily life at home. As Taylor et al. explain: "People constantly combine things in the physical world with their daily lives and different arrangements of social practice to instill wisdom into the family."[14]

5. Future Development of Smart Home
With the integration of smart home products and channels, smart home hardware devices that carry information exchange and consumer services will also organically integrate application scenarios in life. The traditional control method of the absolute center of the smart home is also gradually being abandoned, and the intelligent sense and intelligent interactive experience are being valued by the industry. With the concept of artificial intelligence (AI) empowering the Internet of Things (IOT) being proposed, smart home also have an optimal channel for intelligent upgrades. The integration of voice control, behavior recognition, edge computing, smart sensing, the fifth-generation communications will make the smart home evolve from a controlling role to a platform and medium, integrating more high-quality consumer services. In the future, smart home belongs to the public domain. With the introduction of China's multi-location hardcover housing policies and the rapid advancement of the corresponding market, the whole house intelligence has gradually begun to land. Whole house intelligence means richer combinations and more customized scenarios to meet the needs of different groups of people. At present, the biggest pain point of the smart home industry is that it is unable to realize the intelligent operation and comprehensive interconnection and interoperability of multi-category smart single products in the whole house, and the user experience is cut off. At present, the development direction of China's smart home is in the transition stage from technology-oriented to
user-oriented. The inevitable trend of China's smart home development will be the integration of organic scenarios such as terminals, content, and services. In the future, China's smart home will truly do from the user's perspective, to solve problems for users.

6. Conclusion

The development of smart home is expected to transform the original passive and stationary building into an active and intelligent living space, rely on a full range of information interaction to ensure the smooth communication of information inside the home, and the outside, and optimize user's lifestyle in a highly efficient and low power way. With the people's increasing needs for a better life, it can be expected that in the near future, smart home will also be popularized and become a household standard. The paper discusses the research on the development of smart home. For the future work of this research, through systematic literature review and subject analysis, it summarizes the associations about mainstream research topics, the disconnection between smart home user needs and smart home technologies to develop an organizational framework, to help future researchers navigate the existing smart home research field and plan more effective research approaches.

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