Application of Aging-Appropriate Smart Home in Indoor Living Space

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Abstract. Taking aging as the background, this paper clarifies the application status of smart home in indoor living space and the development trend at home and abroad, analyzes the all-round needs of the elderly for smart home based on the concept of smart elderly care and research results at home and abroad, and expounds the design principles of smart home and related AI technologies. Based on the above research, by proposing the adaptive method of aging smart home application in indoor living space, this paper is committed to exploring more reasonable, more intelligent, and more comfortable and safe indoor living space that is more suitable for the life of the elderly, so as to provide reference opinions for solving the serious aging and old-age problems in today's society.

Keywords: Aging-appropriate · intelligent technology · aged · Interior design · physical and mental needs

1 Current Status of Research in Smart Home in Aging-Appropriate Space

1.1 Research Background of Population Aging

Population aging is a difficult problem facing the whole world. A large number of countries have the problem of intensifying population aging. According to the results of the seventh national population census in 2021, there are 264.02 million people aged 60 and above, accounting for 18.70% (including 190.64 million people aged 65 and above, accounting for 13.50%). [1] Compared with 2012, the proportion of the population aged 60 and above has increased by 4.6 percentage points, which is the highest among all age groups (as shown in the Fig. 1). In this case, China will continue to be affected by population aging for a long time in the future. In this context, the living environment of the elderly has to be paid attention to, and its uncomfortable living environment cannot meet the living conditions of the elderly. In this context, China's traditional pension model is unable to support the current pension pressure. There are many unsuitable factors in the living environment of the elderly. Therefore, there is an urgent need for the development of the pension industry to transform the traditional pension model into a smart pension model in the new era.

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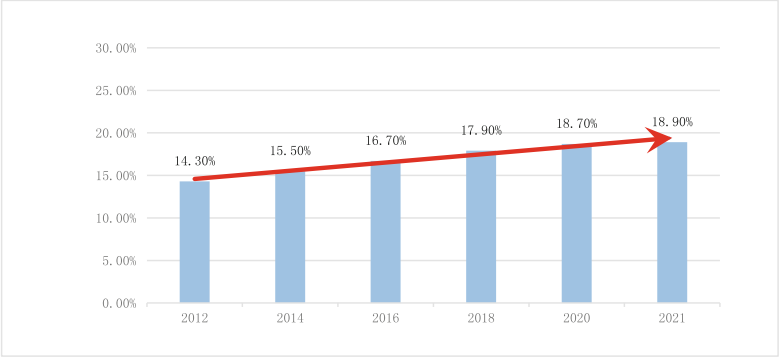

Fig. 1. Development trend of the percentage of the elderly aged 60 and above in the total population of the country

1.2 Current Status of Research in Aging-Appropriate Smart Home

Based on the family living place, smart home integrates the network communication technology, the Internet of Things, artificial intelligence and other intelligent technologies with home equipment to form an intelligent and efficient intelligent home management system. Compared with traditional home, the main advantage of smart home lies in that it can interact with data and can be controlled remotely. At present, according to the research and analysis of CNKI and Wed of Science databases, the domestic research directions pay more attention to such aspects as "home-based elderly care", "elderly care services", "elderly care model", with more emphasis on smart home research in specific environments, including "livable environment", "empty-nest elderly", etc. [2] And also closely related to relevant medical care whose key words include "combination of medical care", "tele-medicine" and so on. However, foreign research focuses on the relationship between the elderly's disease and smart home, and focuses on the aging smart home model and system construction. On the whole, the relevant research fields at home and abroad are extensive, and the ways of intersection between various disciplines are diverse. The relevant theories and technologies abroad are more solid, and the research starts earlier focusing more on the research and development of intelligent technology, while the domestic research focuses more on the social problems of aging and the development of intelligent elderly care products industry. At the same time, it is also further exploring 5G, the Internet of Things, artificial intelligence and other popular industries. Therefore, using technology to meet the biggest demand for the elderly is a necessary way for modern pension methods [3].

1.3 Physical and Mental Needs of the Elderly

With the growth of age, the elderly will face many inevitable changes. While the motor function and perception ability decline, memory and mental decline will follow. [4] In addition with the decline in the sense of their self-identity, they would think that they have no use for the society which further leads to the deepening of psychological problems of

the elderly followed by negative emotions such as loneliness, inferiority, loss. Therefore, it is particularly important to understand the real needs of the elderly.

According to the survey results, nearly 60% of the elderly have used or contacted smart home in their daily life, and they think the convenience and practicality of smart home products are the primary factors. In terms of the functions of smart home products, the respondents have the highest demand for the indoor safety monitoring system and emergency call function, followed by the demand for indoor lighting, indoor environmental control, physical health detection and other aspects. It is obvious that the real needs of the elderly are closely related to the functions of smart home. It is an inevitable choice to introduce smart home into home care and create a better aging space.

2 Relevant AI Technology and Design Principles of Aging Smart Home

2.1 Related AI Technology

With the development of artificial intelligence technology, more and more cutting-edge technologies have been used in the design of smart home. Speech recognition technology, big data, cloud computing technology and wireless communication technology have driven the development of a new generation of smart home.

Speech Recognition Technology

In the smart home system, speech recognition is one of the core technologies to realize remote control. Its essence is to train the feature sequence of speech signal through different speech training recognition algorithms, establish the template of speech recognition, match the input speech sequence with the recognition model during recognition, and then convert the recognized speech signal into corresponding data or commands. At present, the mainstream speech recognition models in the industry include Hidden Markov Model, deep neural network and cyclic neural network. [5] They are mainly applicable to smart speakers, smart lamps, etc., but there are still technical challenges that need to be overcome by researchers. For example, the Mandarin of the elderly is not very standard, and it needs to be repeated many times when calling the wake-up words of smart speakers; when the elderly communicate and chat with smart speakers alone at home, their feedback is relatively single, and they cannot work as a language system close to human beings.

Big Data and Cloud Computing Technology

With more and more intelligent devices in the home, related information such as temperature, pulse, blood pressure are collected by wearing the personal patch in the intelligent device, and a large amount of data such as the temperature, humidity, air quality, etc. provided by various home monitoring devices will be collected and processed on their own servers every day. [6] Based on the analysis of big data, smart home can be close to human experience to improve people's quality of life and provide comfort and happiness. Without manual operation, intelligent equipment automatically adjusts the state of the home environment with appropriate temperature, air humidity and brightness, thus creating a living environment with strong adaptability and distinctive personality.

	Protocol standards	Communication distance	Transmission rate	Power waste	Security
WiFi	IEEE802.11a/b	100-300M	300Mbps	High	Low
Zigbee	IEEE802.15.4	50-300M	250Kbps	Low	Medium
Bluetooth	IEEE802.15.1	2-30M	3Mbps	Low	High

Fig. 2. Comparison of WiFi, Zigbee and bluetooth technologies

The application of cloud computing in smart home is an inevitable demand for the rapid development of a large number of smart devices. The cloud computing used in smart home system reduces the user's personal investment cost for home users, and obtains the application functions that a single device does not have from cloud computing. The centralized data processing method of cloud computing makes technical preparation for the data sharing of smart devices from different manufacturers, and effectively solves the "data silo" problem.[7].

Wireless Communication Technology

As the most important link in the construction of smart home system, the emergence of wireless communication technology effectively simplifies the complexity and disorder of the unit connection between wired communication technology sensors, making a more flexible layout and creating a smart home network. The wireless communication technology mainly includes Zigbee technology, WiFi technology and Bluetooth technology (as shown in the Fig. 2). Zigbee technology is a widely used technology in the field of smart home. Zigbee technology uses the IEEE 802.15.4 standard specification. [8] It has extremely strong network self-organization ability and efficient self-healing ability, and its low cost, low power consumption, and data security. It is a short-range wireless communication technology with many advantages. As the most popular wireless communication technology, WiFi technology has the advantages of strong anti-interference, high transmission rate, low cost, stable performance, and large network throughput. Compared with Zigbee technology, WiFi technology covers a larger area, and WiFi technology realizes the interconnection between mobile end, PC end and smart home. Bluetooth technology is earlier than the two technologies mentioned above. It has this fast speed and high security in the process of data transmission, but at the same time, its transmission distance limit causes Bluetooth technology to be limited to the short distance transmission between mobile devices, and it is difficult to occupy an important position in the smart home system. It makes more use of one-to-one communication methods such as Bluetooth headset and health detection equipment.

2.2 Design Principles of Aging-Appropriate Smart Home

Safety Principle

The safety principle is the prerequisite of all smart home design principles. As the elderly's motor function and perception ability gradually decline, their actions begin to become slow, their visual perception decreases, and their hearing is also declining.

The study found that nearly 65% of the elderly in China have hearing impairment. These factors make it impossible to measure the aging-appropriate smart home from the design perspective of ordinary people. Smart home should be made of soft materials to the maximum extent, and hard materials should have a smooth surface; An appropriate amount of auxiliary handrails should be arranged at the appropriate position to ensure that the elderly with mobility difficulties can rely on them. Safety should not only be ensured in the appearance of smart home, safety protection functions should also be guaranteed for instance intelligent detection of heart rate, blood pressure, physical condition, etc. of the elderly, alarm system and remote transmission to timely convey the situation to the family, intelligent access control and alarm system that ensure the safety of the elderly.

The Principle of Inclusiveness

Research shows that the detection rate of mild cognitive impairment (MCI) in the elderly aged over 60 years in China has reached 12.7%. [9] With the decline of the mental ability and cognitive level of the elderly, it is inevitable that the instructions given to the smart home are inaccurate. In the design and development of the smart home, the operating instructions must be clear and clear, and should not be ambiguous. The instructions should be as simple as possible, and should be more inclusive. Secondly, we should include people of both sex and different ages to the maximum extent in order to ensure the universality of intelligent products, and make it truly barrier-free. In addition, it requires not only its own inclusiveness, but also the strong inclusiveness of the entire aging space. The design scale should match the space. Smart home should be arranged without affecting the daily life and traffic of the elderly so as to realize the integration of aging-appropriate space and smart home.

The Principle of Spiritual Consolation

When designing aging-appropriate smart home, embodiment of the social value of the elderly should be taken into account to give them the greatest spiritual consolation. Some intelligent monitoring devices should covertly realize the monitoring function to avoid some mentally sensitive elderly people from reducing their sense of identity, which may lead to depression, loss, fear, and even the idea of suicide. In addition, we should actively cater to the elderly by improving their emotional experience when using, making them happy physically and mentally, enhancing their sense of belonging so as to establish human-computer harmonious relationship and awaken the elderly's positive and healthy emotions.

3 Design Strategy of Aging-Appropriate Smart Home in Indoor Living Space

3.1 Bathroom

As the area most prone to accidents in the daily life of the elderly, the bathroom is undoubtedly the key part of smart home participation [10] First of all, we should ensure that the movement line in the bathroom is smooth without hindering the action of the elderly by arranging the necessary smart home reasonably. The intelligent toilet is an

essential smart home in the bathroom. It has the functions of automatic cleaning, warm air drying, odor elimination, health detection, and body condition analysis using excreta. A handrail should be installed beside the toilet at the height of about 700mm, or around the lower chest position of the elderly, which is convenient for getting up after using the toilet, so as to avoid falling due to insufficient blood supply to the brain. In the bathroom, the washbasin should be suspended at the height if 800mm from the ground to facilitate the elderly to enter in a wheelchair. The intelligent sensing faucet should be used to reduce the operation of the elderly. The retractable intelligent mirror should be used to for the convenience of family members of different heights. The automatic drying and sterilizing towel rack should be equipped to prevent bacteria from growing in the wet towel. In the bathroom, dry and wet area should be separated, and highly anti-slip bricks should be used to avoid slipping to the maximum extent. When the shower head in the bathroom is turned on, the intelligent fresh air system should be automatically started and set to the air heating mode to ensure the indoor temperature during bathing. After bathing, the fresh air circulation system should be automatically turned on to discharge the moisture and heat in time. If there is an accident where the elderly accidentally falls to the ground, an infrared sensing device applied near the ground should detect it immediately and start the alarm and the information will be transmitted to the mobile terminal of the family through big data technology at the first time.

3.2 Bedroom Space

The bedroom space is a space to for the elderly to sleep, which is the most important part of keeping healthy. Therefore, the temperature, humidity, lighting, air quality, etc. should be highly required to ensure the comfort of the elderly and improve the quality of rest. The clear width of the main passage in the bedroom should be greater than 900mm. The furniture layout should consider leaving a 1500 * 1500mm space for 360 degree rotation of the elderly's wheelchair (as shown in the Fig. 3). The intelligent nursing bed should monitor the physical condition of the elderly in real time, and can also be equipped with intelligent massage mattresses to help the elderly relax. The space is equipped with an intelligent control system with multiple modes switchable automatically by using voice control technology, such as "sleep mode", "reading mode", "wake up mode", etc. With the issuance of the control command, the lighting, curtains, fresh air system, etc. in the space are adjusted to corresponding modes to achieve a truly comfortable and intelligent bedroom space. The intelligent bedside table should be reasonably placed with drugs and nutrition products, and the elderly should be reminded to take drugs regularly. There is also an emergency call button on its panel to ensure that the elderly can save themselves in time. In addition, taking into account the emotional needs of the elderly, the intelligent voice assistant should be equipped to accompany the elderly when they are bored by telling social news, anecdotes, and chatter about family affairs, so that the elderly do not feel lonely.

3.3 Living Room Space

The living room space is the main place for the elderly to live and relax in their daily life. It is necessary to meet the needs of the elderly to meeting family and friends, leisure

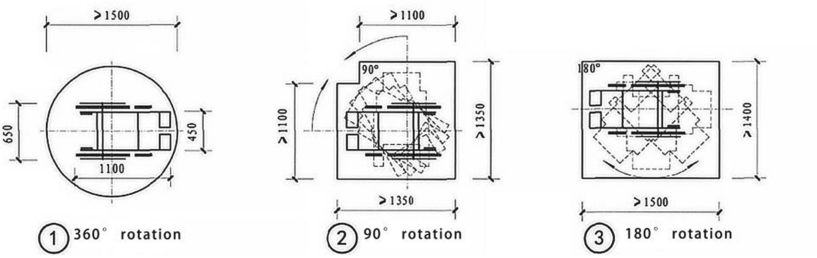

Fig. 3. Diagrammatic sketch of wheelchair rotation

activities, reading and reading newspapers, etc. on the premise of ensuring safety. The furniture in the living room should also need a wide aisle for rotation and placing of the wheelchair, and the sofa and coffee table can be movable and adjustable to facilitate the moving of the elderly. The sofa should be equipped with complete intelligent technology to monitor the physical condition of the elderly from time to time and upload it to the network terminal for analysis. The intelligent coffee table should have heating function to ensure the elderly's drinks are warm. Same as the bedroom, the space should be equipped with corresponding intelligent systems to meet the use of various modes, and the whole house intelligent network system is built through the combination of WiFi technology and zigbee technology, so as to keep the whole house intelligent at all times. If there is enough space, it can be equipped with intelligent massage chairs and intelligent rehabilitation equipment to meet the needs of the elderly to carry out rehabilitation training at home.

3.4 Dining Room and Kitchen

The elderly tend to cook by themselves, and this operation with their hands can alleviate the effects of Alzheimer's disease and also very healthy. In the kitchen the movement line should be smooth and there should be no problems such as narrow aisle, dim light or lack of storage space. Intelligent kitchen appliances should be convenient to operate by the elderly. The simple and clear intelligent stove should not require the repeated operation, and should be equipped with smoke detection alarm, water flow detection alarm, gas alarm, etc. to ensure the safety of fire and water use for the elderly. The double-door intelligent refrigerator should be used to ensure a large amount of storage space, and the self-circulation system should be added to ensure the long-term preservation of food. The kitchen should be equipped with a fresh air system to timely remove harmful gases and circulate indoor air. In the dining room, the integrated table should separate the food preparation area and should be equipped with intelligent heating equipment to keep dishes warm.

4 Conclusions

At present, the utilization rate of smart home in the aging-appropriate space is still low. The smart pension system is taking shape, but it is still in the key stage of transformation to a complete system. Through the research on the physical and mental needs of the

elderly, combined with the key artificial intelligence technology of smart home, this paper expounds the design principles of aging-appropriate smart home, summarizes the optimization design strategy of smart home in the aging-appropriate space so as to create a more suitable environment for the elderly to live at home by improving the living efficiency and reducing the living costs of the elderly using intelligent ways. With the development of the society and the popularization of intelligence, smart home shall played a decisive role in the pension system. At the same time, smart home design should pay more attention to the physical and mental needs of the elderly and create more diverse and more adaptive smart products in order to make the smart pension system more perfect and bring more possibilities for the future pension model.

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