Analysis and Design of Interior Space for Elderly under the Background of Smart Elderly Care

Tao Yang[*] and Yong Zhang

{[*]Corresponding author: 806009741@qq.com}
{2542931073@qq.com}

Shenyang Jianzhu University, Shenyang, Liaoning, China

Abstract. Mobile communication technology and devices are gradually changing people's way of life. In today's aging population society, smart elderly care is gradually becoming a retirement model that can better meet the elderly's elderly care needs. Based on the physiological and psychological needs of elderly space design, this article presents the structure of a smart elderly care space environment, which can be divided into perception layer, network layer, and application layer. This article provides the key points of intelligent design for elderly indoor space environments, such as restaurant and kitchen design, bedroom design, and bathroom design. The application of intelligent sensing systems, various intelligent terminal devices, and intelligent interaction systems in elderly living spaces can improve the quality of life and living of the elderly, and better meet their intelligent elderly care needs.

Keywords: Interior Space, Interior Spatial Environment, Smart Elderly Care

1. Introduction

China's aging rate and scale are unprecedented. As of the end of 2021, the population of elderly people aged 60 and above in China reached 267 million, accounting for 18.9% of the total population. According to calculations, it is expected that during the 14th Five Year Plan period, the total number of elderly people aged 60 and above will exceed 300 million, accounting for over 20%. China will enter a stage of moderate aging in 2025. Around 2035, the elderly population aged 60 and above will exceed 400 million, accounting for over 30% of the total population, and China will enter a stage of severe aging. The new generation of information technology has provided the foundation for the development of smart elderly care. The concept of "Internet of Things" provides a new and faster path for multi-party collaboration in the elderly care industry. This technology can create a comprehensive, systematic, and efficient feedback environment, enabling timely and rapid monitoring and management of the physical health, safety status, and psychological needs of the elderly. While ensuring privacy, it also meets various needs of the elderly in their daily care. Due to the degradation of various physical functions in the elderly population, there is an urgent need for intelligent facilities and equipment such as safety alarms and health

monitoring to ensure their safety and provide comprehensive care for the elderly [1]. Faced with the current social situation of China's aging population and combined with the new generation of mobile communication technology, this article conducts research on residential space under the smart elderly care model, aiming to better meet the special psychological and physiological needs of elderly care in China, and better respond to the increasing demand for residential space from traditional elderly care space to smart elderly care model. This article expands the possibilities for the future living space of the elderly, with the aim of providing certain design reference for the design of living space under the smart elderly care model in the future.

2. Demand Analysis of Interior Space for Elderly

2.1 Physiological Demands Analysis

The physical functions of elderly people will gradually weaken with age, and issues related to metabolism, geriatric diseases, cardiovascular and cerebrovascular diseases will also become increasingly prominent. This provides a fundamental design approach for the construction of an elderly friendly environment [2]. The first issue is physical fitness. Entering the old age, the physical strength and endurance of elderly people weaken, and problems such as hunchback and osteoporosis limit their behavior. The flexibility and responsiveness of their movements also decrease accordingly. Some physical activities, such as climbing, lifting heavy objects, and vigorous exercise, are no longer suitable to continue, which can easily lead to falls, fractures, and waist injuries. Secondly, there is the issue of geriatric diseases. In addition to the natural decline of physical functions, most of the elderly now work too hard and do not pay attention to physical maintenance when they are young, which has also become one of the incentives for high incidence of hypertension, rheumatism, diabetes and other diseases in the elderly. Diseases affect the physical health, emotions, and family of elderly people, therefore, the promotion of the combination of medical and nursing care is extremely important. Among elderly diseases, there are also mental illnesses such as Alzheimer's that require long-term care and treatment [3]. This type of elderly people's ability to receive and process new information has significantly decreased, and they need familiar environments and care, which puts forward requirements for the construction of elderly care environments in new communities. Finally, there are sensory issues for the elderly. Hearing loss, weakened vision, and sensory degradation are key areas that the elderly population needs to pay attention to in their elderly care. For example, elderly people's perception and adaptability to temperature are significantly weakened compared to adults. In situations such as rapid cooling and heating, untimely care may lead to sudden illnesses or even concomitant diseases. The lighting standards for the elderly are shown in Table 1, and the noise standards for the elderly are shown in Table 2.

Table 1. Lighting standards for the elderly

Room	Functions	Reference plane	Illuminance standard value (lx)

Living room	Walk	0.75m horizontal plane	150
Living room	Read, write	0.75m horizontal plane	300
Bedroom	Walk	0.75m horizontal plane	150
Bedroom	Bedside reading	0.75m horizontal plane	200
Aisle	Walk	0.75m horizontal plane	100
Restaurant	Eat	0.75m horizontal plane	200
Kitchen	Operate	Table	200
Toilet	Urinate	0.75m horizontal plane	150
Toilet	Wash	Table	200

Table 2. Noise standards for the elderly

Room	Allowable noise level (Level A) dB			
	Recommended value		Max value	
	Day	Night	Day	Night
Bedroom	40	30	37	45
Living room	40		45	

2.2 Psychological Demands Analysis

Entering the old age, retirement keeps the elderly away from production and living activities, which greatly increases their leisure time and their dependence on their spouse, children, and living environment. Based on this situation, it is possible to analyze the collective and universal psychological changes that may occur in the elderly during the elderly care stage, as well as their root causes [4]. After retirement, elderly people become dependent populations, separated from their original social environment and interpersonal relationships, coupled with the impact of weakened physical functions, resulting in a corresponding reduction in their life circle and available social activities, which easily leads to feelings of loneliness and emptiness among the elderly. At the same time, the loss of a fixed source of income caused by retirement or the economic pressure caused by diseases such as geriatric diseases place the elderly in a lower social status, which may lead to anxiety, self-blame, and even depression in severe cases. Moreover, the traditional concept of elderly care holds the mainstream in the cognition of the elderly population in China. Most elderly people hope to live with their children and grandchildren, but conflicts such as long-distance issues and low popularity of aging friendly residential design have deterred them. According to Maslow's hierarchy of needs theory, the psychological needs of the elderly can be mapped to five major needs: physiological needs, that is, to ensure the basic living needs of the elderly, such as clothing, food, housing and transportation; The demand for safety requires the cooperation of children, grandchildren, and social resources to maintain stable and good family relationships with the elderly, and to ensure their safety in life with a complete aging environment construction; The need for belonging, appropriate neighborhood relationships, and social connections can satisfy the social needs of the elderly, generating a sense of belonging that is recognized and accepted by society. The need to be respected by

others is to identify with the needs, ensuring that the elderly have a sense of privacy and sense of privacy. The Chinese government and all sectors of society should also give corresponding respect to the transformed social identity, personal abilities, and rights of the elderly; The need for self-realization is manifested in the pursuit of personal achievement by elderly people during the elderly care process: hoping to still contribute to society, continue to shine in certain fields, and unleash their self-worth [5].

3. Structure of Interior Space of Smart Elderly Care

3.1 Overall Structure

The technologies of big data, cloud computing, and the internet of things are used to establish an information system structure of the smart elderly care space environment, which is shown in Fig. 1.

From top to bottom, it includes three levels: perception layer, network layer, and application layer. The perception layer applies various sensors to collect various basic information of the elderly; The network layer is used to collect, store, and process relevant information, establish a database, and manage it through intelligent terminals; The application layer implements the specific deployment of applications to achieve intelligent decision-making in buildings. By constructing three levels, comprehensively analyzing the application of information technology in space, and exploring the correlation and coupling between smart elderly care and architectural space [6].
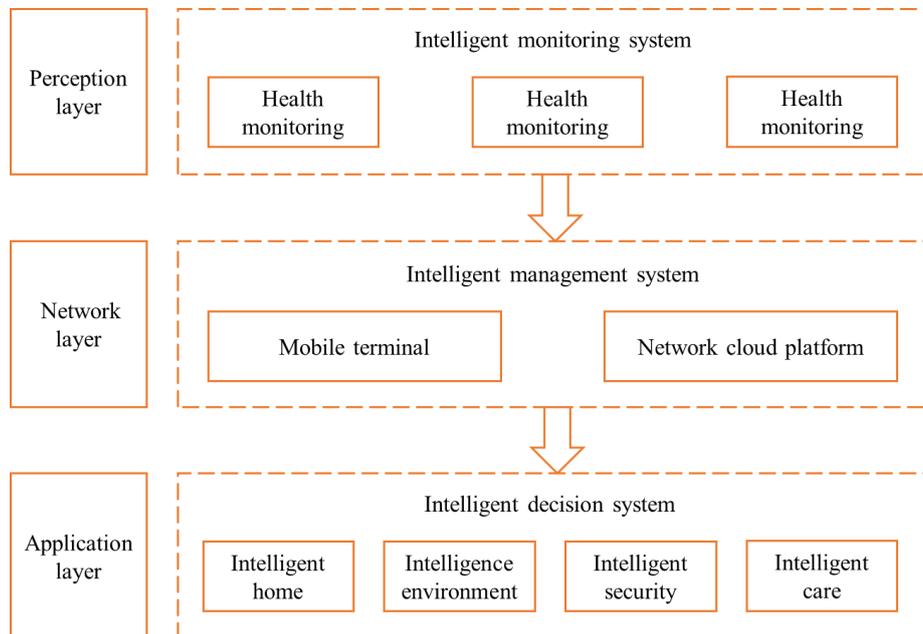
Fig.1   Structure of interior space of smart elderly care

3.2 Perception Layer

The perception layer is the grassroots structure in smart elderly care systems, and its application in elderly care mainly involves monitoring the physical health, behavior, and emotions of the elderly through sensing devices. Based on the movement characteristics and physical functions of the elderly, suitable elderly sensing facilities are equipped in the space of buildings related to the elderly to ensure their safety [7]. Common intelligent elderly care facilities, medical and healthcare facilities include intelligent integrated machines, rehabilitation training facilities, and wearable health monitoring bracelets. Daytime care facilities include care robots, and intelligent bathrooms. Cultural and entertainment facilities include remote videos, intelligent companion robots, etc. In terms of health monitoring, intelligent health devices are used to provide elderly people with services such as measuring blood pressure and blood lipids, which can quickly analyze data and undergo health assessment tests, and be integrated into the system. Real time monitoring of the vital signs of the elderly throughout the entire process. In terms of behavior monitoring, video surveillance systems are mainly used to record the activities of the elderly in the space. Emotion monitoring mainly utilizes intelligent emotion monitoring technology to extract facial features of elderly people, in order to better understand their physical and mental health. Facial recognition mainly applies video capture and expression analysis systems, which capture the facial expressions of elderly people, analyze their facial muscle movement changes, and accurately identify the eight basic emotions of the elderly. The basic emotions of the elderly are shown in Table 3.

Table 3. Basic Emotions of the Elderly Recognized by Information System

Number	Parameter	Performance	Number	Parameter	Performance
1	Satisfaction	Happy	5	Disgust	Disgusted
2	Sadness	Depressed	6	Contemplation	Thinking
3	Anger	Angry	7	Surprise	Excited
4	Tension	Nervous	8	Expectation	Expectant

3.3 Network Layer

The network layer is the intermediate layer of intelligent elderly care, which completes the transmission, processing, and storage of information, and aggregates and sends the information received by the perception layer to the network [8]. By developing a smart management platform, an information-based elderly care service system can provide a foundation for decision-making at the application level. The smart elderly care service platform is based on advanced technologies such as the Internet, the Internet, big data, and cloud computing. Using mobile devices such as mobile phones and tablets as terminal platforms to obtain information on the needs of the elderly, it mainly includes five modules. Among them, the basic information module is used to display information such as the name, age, contact information, and past medical history of the elderly; The real-time status module is used to monitor and store various physiological and psychological indicator data of the elderly, and automatically generate health reports [9]. The reminder warning module is used to regularly remind events such as eating, sleeping, and medication, and to set

emergency call buttons to respond to abnormal or unexpected situations; Service demand module, used for daily needs such as shopping and ordering of elderly people; The medical rescue module synchronizes elderly data to medical institutions such as nursing homes and hospitals, facilitating remote doctor monitoring and emergency treatment work. Network cloud platform. The elderly information transfer service platform that integrates software and hardware resources mainly includes three modules. Among them, the data management module is used for the storage and management of various data of the elderly, and classifies the data of the home gateway into daily reports, reminders and warning events; Equipment management module, used for binding and linkage management of various intelligent elderly care devices and terminals; The user management module is used for identity authentication, role setting, and permission management of elderly people, family members, communities, nursing homes, hospitals, and other users.

3.4 Application Layer

The application layer of the smart elderly care space environment system collects information about the elderly through information technology networks, ensuring internal environmental and security control. With the home automation system as the core, it uses micro processing electronic technology to receive the instruction information from mobile terminals and feed back to the refrigerator, air conditioner, microwave oven, rice cooker, vacuum cleaner and other electrical equipment in the house in real time, so as to realize the one touch control of household appliances and provide life support and personalized services for the elderly. The intelligent environment system adjusts the physical environment by controlling the opening and closing status of various facilities in the space, including controlling the sound, light, heat, and other environments of the building. Intelligent control of thermal ambient intelligence, which uses sensor system to control the heat exchange through the enclosure structure, and is supplemented by artificial cold and heat sources to ensure the indoor temperature and humidity; Air ambient intelligence intelligent control ensures fresh air volume and air cleanliness by controlling window opening, air conditioning and purification equipment. The intelligent security system mainly achieves security protection for elderly people's daily activities in the space through access control, video surveillance, and emergency assistance. This includes a security defense system that utilizes monitoring equipment to achieve real-time tracking and abnormal behavior monitoring of the elderly, in order to prevent them from becoming dangerous due to illegal invasion or criminal incidents. The intelligent care system is guided by the needs of the elderly, using mobile terminals and intelligent elderly care service platforms as carriers to provide an intelligent care system for the elderly. Utilize mobile terminals such as mobile phones and tablets to ensure regular communication between the elderly and their children, and configure nursing robots that can respond instantly to the elderly's voice commands, body behavior, and body data, providing wholehearted care for the elderly [10].

4. Design of Interior Space for Elderly under the Background of Smart Elderly Care

4.1 Bedroom Design

An induction light is installed under the bed in the bedroom of the elderly. When the elderly is active in the sleep area at night, the induction light automatically lights up, creating a good sleep environment atmosphere and providing lighting to reduce the risk of bumps and even falls for the elderly. The bed is equipped by intelligent sensing technology: intelligent mattresses, intelligent pillows, and intelligent quilts. Intelligent mattresses and pillows can monitor the sleep, bedtime, and physical health of the elderly, and transmit data in real-time to intelligent service platforms [11]. When abnormal situations occur, powerful algorithmic platforms such as AI can provide real-time alerts and arrange service personnel to come to the door to provide assistance. Intelligent quilts can monitor environmental temperature and the body temperature of the elderly, with cooling, insulation, and heating functions, providing the most suitable and comfortable temperature for the elderly. Human infrared sensing alarm: It can detect the status of elderly people getting out of bed, getting up at night, and falling. If they cannot stand up for a certain period of time, it will trigger an alarm, and specialized medical service personnel will come to check the situation. Door magnetic detection alarm: When the door is abnormally opened or it is recognized that it was not the person who opened the door, the information will be synchronized to the phone to determine whether the alarm is triggered. The smoke detection alarm can detect whether there is a fire or smoke inside the house. If there is already a related fire, it will immediately start sprinkling water and alarm in a timely manner. Air quality monitoring alarm: It can purify the air, detect floating dust, PM2.5, etc. in the air, and maintain air quality standards at any time. A smart medicine box is installed in the bedside table, which can automatically remind elderly people who need to take medication regularly. In case of forgetting to take medication or missing dosage, the smart medicine box can send an alarm to the intelligent service platform and family, further reminding elderly people who need to take medication scientifically, safely, and regularly. A one button wireless alarm device is installed above the bedside table. When elderly people living alone, empty nests, or in need of assistance encounter dangerous situations, the one button wireless alarm device can facilitate the elderly to seek help. In addition, the air quality monitoring alarm can monitor environmental quality in real-time. The clicks wireless alarm device and air quality monitoring alarm can timely send alarms to the intelligent service platform, family mobile phones, and service personnel mobile phones [12].

4.2 Restaurant.and Kitchen Design

The restaurant area is an area that provides dining scenes for the elderly, while the kitchen area is an area that provides cooking scenes for the elderly. In addition to dining, restaurants can also improve their quality of life through the multifunctional interaction system of smart screen terminal devices, which is a smart large screen. This allows elderly people to share cloud videos, cloud hotpot, and cloud movies with friends while eating, making the environment for elderly people to cook and eat less boring. In terms of lighting, the restaurant has a lighting adjustment system based on intelligent sensing technology. If the weather changes from sunny to cloudy, the sensing light will also turn from dark to bright. In order to ensure the safety of elderly cooking, the kitchen has set up an intelligent sensing system for environmental quality parameters, such as a smoke detection alarm. If a fire occurs, it will immediately

alarm and sprinkle water. Equipped with infrared body sensing devices and intelligent recognition cameras, these devices immediately recognize the elderly's condition when they fall or have an accident, call the police, and seek help. In order to make cooking more convenient for the elderly, the kitchen is equipped with intelligent terminal devices based on Internet of Things technology, such as smart stoves, smart smoking machines, smart refrigerators, smart rice buckets, automatic dishwashers, pull-down storage compartments, etc., allowing intelligent products to help the elderly cook quickly and conveniently. Associate the intelligent devices in the kitchen with the intelligent control system and preset the cooking mode and departure mode. After activating the departure mode, all devices will be turned off; When cooking at night, the lamplight provided by the range hood may have a problem of insufficient light. An induction fill light is installed below the storage cabinet in the area near the stove to automatically fill the light when the light is insufficient. In terms of safety, it is necessary to install water leakage monitors and natural gas detectors.

4.3 Toilet Design

The washing area is equipped with an aging friendly washing table and intelligent makeup mirrors. The faucet adopts an induction water outlet, leaving space under the washing table for the convenience of elderly wheelchair users. In addition to being equipped with LED lights, intelligent makeup mirrors can meet the high-quality dressing needs of the elderly. They also apply display technology. Intelligent makeup mirrors can be used for makeup and can also serve as screens. The touch and voice controlled large mirror screen can meet the audio-visual needs of the elderly during washing time, such as watching news, weather, live streaming, listening to radio, reading notes, and video calls. Set up an intelligent toilet in the toilet area. The intelligent toilet has many automatic functions such as automatic cleaning and automatic washing. When the elderly approach or leave the toilet, the intelligent toilet cover can automatically open or close. After the elderly have finished using the toilet, the intelligent toilet can provide clean and comfortable automatic warm water flushing for the elderly. When the toilet area needs to be manually cleaned, the intelligent toilet can prompt the elderly or automatically transmit information to the comprehensive service platform, The service personnel will come to the door to provide artificial hygiene and cleaning services. Foldable armrests are installed on both sides of the toilet, allowing the elderly to grab and hold the toilet when standing up, and to fold it up when not in use, making the use of the smart toilet more accessible. The shower area is equipped with intelligent sitting showers and intelligent bathtubs. The design of the folding seat and the adjustable sprinkler of the intelligent sitting shower can meet the needs of the elderly for a short time standing shower and sitting safety shower. The magic massage bathtub technology and space sleep bathing technology of intelligent bathtubs can bring more comfortable bathing experiences to the elderly.

5. Conclusions

The article analyzes the physiological and psychological needs of elderly space design in the context of smart elderly care, and provides the basic structure and design points of elderly space design. The elderly's elderly care life cannot be limited to meeting

basic food and housing needs, but should pursue a higher level of quality of life. On the basis of the perfect guarantee of the smart elderly care system, architectural design should focus on comfort and convenience; When elderly people leave their homes and walk in public areas of the community, the design should consider how to meet the entertainment environment facilities of different age groups, making it convenient for everyone to engage in entertainment and socializing. In the design of environmental facilities that meet the interests and hobbies of the elderly, it should be tailored to each individual and fully investigate their preferences. The environmental design should focus on the elderly as the service center, and fully consider the wishes and feelings of the elderly while meeting their usage needs. In the design and development of environmental facilities relying on smart elderly care, it is necessary to keep up with the times and pay more attention to the application of new and user-friendly technology.

References

[1] Delcampo‐Carda A, Torres‐Barchino A, Serra‐Lluch J. Chromatic interior environments for the elderly: A literature review[J]. Color Research & Application, 2019, 44(3): 381-395.

[2] Li S, Abidin S Z, Ren S, et al. Research on Modern Kitchen Design Based on the Storage Behavior of Chinese Elderly[J]. International Journal of Advanced Research in Education and Society, 2023, 5(1): 169-177.

[3] Gharaveis A. A systematic framework for understanding environmental design influences on physical activity in the elderly population: A review of literature[J]. Facilities, 2020, 22(12): 201-210.

[4] Wang X, Shi R, Niu F. Optimization of furniture configuration for residential living room spaces in quality elderly care communities in Macao[J]. Frontiers of Architectural Research, 2022, 11(2): 357-373.

[5] Tsai S Y, Hong S Y. Influence of multisensory stimulation environmental designs for day services and healing environment of elderly people with dementia[J]. Sensors and Materials, 2019, 31(5): 1739-1749.

[6] Jung C, Mahmoud N S A, El Samanoudy G, et al. Evaluating the color preferences for elderly depression in the United Arab Emirates[J]. Buildings, 2022, 12(2): 234-236.

[7] Sánchez S N V, Mahaek E, Lekagul A. A framework of design criteria for elderly facilities using Maslow's hierarchy of needs[J]. Nakhara: Journal of Environmental Design and Planning, 2020, 18(2): 97-116.

[8] Kim J W, Kim W P. A Study on the Barrier-free Space through IPA Method for the Elderly in Multi-family Housing[J]. Journal of the Korea Convergence Society, 2020, 11(1): 187-194.

[9] Jarutach T, Lertpradit N. Housing conditions and improvement guidelines for the elderly living in urban areas: Case studies of four Bangkok's districts[J]. Nakhara: Journal of Environmental Design and Planning, 2020, 18(6): 117-138.

[10] Zhang Q, Li M, Wu Y. Smart home for elderly care: development and challenges in China[J]. BMC geriatrics, 2020, 20(1): 1-8.

[11] Zhu J, Shi K, Yang C, et al. Ethical issues of smart home‐based elderly care: A scoping review[J]. Journal of nursing management, 2022, 30(8): 3686-3699.

[12] Yang M, Tian X, Hua T. Transparent, Stretchable, and Adhesive Conductive Ionic Hydrogel-Based Self-Powered Sensors for Smart Elderly Care Systems[J]. ACS