



# Research on the Design of Indoor Facilities of Intelligent Senior Housing Based on Behavioral Characteristics of Alzheimer's Patients

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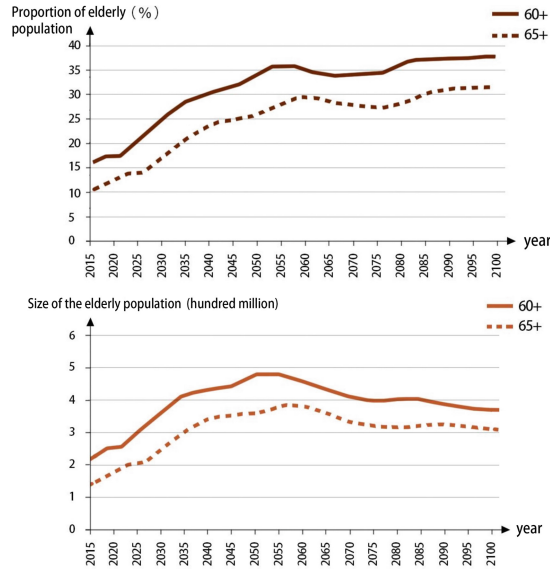
**Abstract.** In the context of global aging, the number of Alzheimer's disease (AD) patients is increasing dramatically. In the process of caring Alzheimer's patients, the patients have some unstable, illogical and dangerous behavioral problems. With the increasing development of big data, artificial intelligence, and Internet of Things technology, the rational use of smart home concept, combined with accessibility design specifications, to establish to a more complete, comfortable, and healthy living space for Alzheimer's patients, improve their ability to live independently, alleviate their disease development, and reduce the burden of caregivers, is the focus of this thesis research.

**Keywords:** Alzheimer's disease · smart home · indoor facilities

## 1 Introduction

According to the internationally accepted classification standard, when the proportion of population aged 65 and above in a country or region exceeds 7%, it means entering aging; reaching 14%, it is deep aging; exceeding 20%, it enters a super-aging society. [1] According to the data of the seventh population census, China has gradually entered an aging society, and the proportion of people aged 60 and above has increased by 5.44% in the past decade, reaching 264 million people, accounting for 18.9% of the national population; the proportion of people aged 65 and above has increased by 4.63%, reaching 190 million people, accounting for 13.5% of the national population. In the general trend of population aging, the number of Alzheimer's elderly is increasing.

In recent years, AI has become more and more widely used in various fields of society. In agriculture and industry, AI can perform automatic irrigation, automatic seeding, product inspection, virtual online sales and manufacturing of various electronic products; in public services, AI can brush face payment, face recognition of criminals; in health, AI can do disease risk prediction, disease diagnosis, health care, home health management, and even more, surgical robots and rehabilitation robots to assist in treatment. [2] (Fig. 1).



**Fig. 1.** Trends in China's Population and Aging, 2015–2100

## 2 Behavioral Characteristics of Alzheimer's Patients

Alzheimer's disease is the most prevalent form of dementia, accounting for more than 70–80% of all cases. Early symptoms are constant forgetfulness of things that happen in the short term, such as frequently losing track of time and forgetting what they have just done, and in the gradual deterioration of the disease, the patient's physical functions gradually decline. AD has risen from tenth to fifth place in the ranking of the top ten age standardized causes of death in China from 1990 to 2019. The China Alzheimer's Disease Report 2021 shows that the number of existing Alzheimer's disease patients and other dementia cases in China in 2019 is 13,244,000, with a common starting age of 60 or less than 65 years old, and is predicted to reach 22.2 million in 2030 and 28.98 million in 2050, accounting for 6% of the elderly population (Fig. 2).

AD is a degenerative disease of the brain that is incurable until now, and the psychological and behavioral characteristics of patients change dramatically from the early stage of recent memory loss to the middle stage of gradual loss of self-care (Fig. 3). In response to this series of phenomena, artificial intelligence technology with high accuracy, high efficiency, and long duration has become an important way to improve the quality of life of patients, reduce the risk of patient injury, and alleviate the mental stress and physical strain of caregivers. This paper reviews the types, characteristics and roles of smart homes applicable to AD patients in home care, and provides references for research on how smart home products can better help patients and their caregivers.

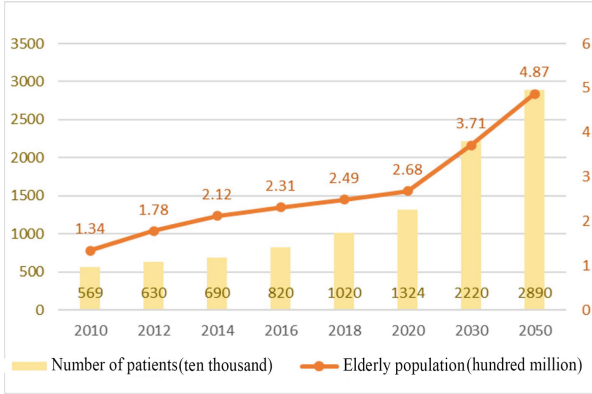


Fig. 2. Trends of AD patients and elderly population (60+ years old) in China

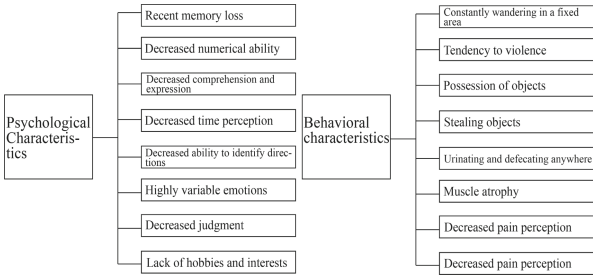


Fig. 3. Psychological and behavioral characteristics of Alzheimer's patients

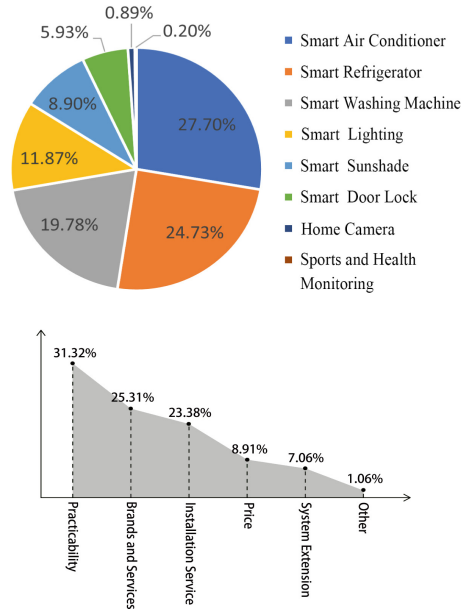
### 3 Status of Smart Senior Housing

#### 3.1 Smart Home Concept

Artificial intelligence (AI) is an emerging discipline based on the research and development of various interdisciplinary disciplines such as computer science, neurology, linguistics, control and information theory, which can simulate human thinking, recognize complex situations, acquire learning abilities and knowledge, and solve problems [3]. In recent years, AI has been widely used in the family home, and its core is to connect various electronic devices in the home with 5G technology through an IoT platform to provide a full range of information interaction functions. For AD patients, smart homes can meet their needs for high-quality care, improve the safety and comfort of home care, maximize patients' capabilities, and also reduce the work pressure of caregivers.

#### 3.2 Status of Intelligent Nursing Housing

The direction of the development of intelligent nursing technology mainly focuses on communication, control and data processing, medical technology and assistive devices,



**Fig. 4.** Market share of main products of smart home and concerns of users choosing to install smart systems

etc. In terms of technology form, intelligent products for the elderly are mainly manifested in remote monitoring technology, wearable technology and intelligent robots [4]. For example, the “Vera III” produced by Shanghai’s Freeway Intelligent Robot Company can help the elderly with schedule management, safety monitoring, information inquiry and other services; the Resone machine wheelchair bed produced by Japan’s Panasonic Corporation integrates electric care beds and fully automatic adjustment wheelchairs, helping the elderly to switch between wheelchairs and beds more comfortably [5]. Apple’s “Siri”, Baidu’s “Xiaodu” and other voice assistants also provide emotional design for the elderly. Smart home will become the ideal state of the future home, and its market prospect is huge (Fig. 4).

## 4 Interior Design Strategies for Smart Nursing Housing Suitable for Alzheimer’s Patients

### 4.1 Smart Nursing Content

#### 4.1.1 Spatial Scale

AD patients in the medium term may have reduced mobility due to muscle atrophy and the need for wheelchairs, so all doors in the residence should be wider than 900 mm, with the floor leveled to prevent patients from falling and safety handrails designed on the walls to facilitate patient walking assistance. As far as possible, the patient’s activity line should be designed in a simple one-line or T-line shape, running through the living

room, kitchen and bedroom, which is conducive to the patient's identification of the overall situation in the space. The caregiver's patient's bedroom should preferably be close by, and the patient's room should be kept somewhat permeable so that its condition can be viewed at any time (Fig. 5).

Intelligent door locks are set at the entrance to prevent patients from getting lost. Considering the convenience of stretcher access during emergency, the net width of the household door should be greater than 1000 mm, the vertical safety handrail required for standing is installed next to the door, the height of the top at the shoulder position is about 1400 mm, and the distance from the terminal is 700 mm, and the parallel handrail required for walking is installed at the passage, the height is 700 mm–800 mm.

As a frequently used high-risk area, the bathroom should be designed close to the patient's bedroom so that it can be used at the fastest speed, but a separate bathroom should not be set up in the patient's room to prevent danger in the absence of cognitive function and safety awareness. The barrier-free design inside the bathroom is especially important. Considering that some patients need wheelchairs to walk for them, the bathroom needs to have a wheelchair turning space with a diameter of not less than 1500 mm; the sink and toilet are designed with wall-mounted design, with an interval of not less than 200 mm and 650 mm from the ground, which is convenient for wheelchairs to turn in the bathroom; a one-touch call button is set at 300 mm from the ground in front of the toilet diagonally. The lower end of the pull cord is 100 mm from the ground to ensure that patients can call for help even if they fall; the intelligent water immersion alarm is set at 100 mm above the ground to prevent water immersion. (Fig. 5).

#### **4.1.2 Private Space**

Patients with AD often wander around the house, are emotionally volatile and irritable, and are destructive to their surroundings; cognitive decline also makes them susceptible to accidentally taking and inhaling dangerous substances, so specific areas of the home need to be closed off. Kitchens, pantries, and freezers should not be open, and electronic locks should be installed for caregiver use only.

Some AD patients often have the psychological feeling that they are being stolen from and want to hide everything. Therefore, in the design, valuables and the caregiver's personal belongings need to blend in with the surrounding space and try not to let the patient focus on them.

#### **4.1.3 Space Soft Decoration**

In home soft furnishings, the material of the seat and sofa should be made of removable and waterproof material to facilitate timely replacement when the patient is incontinent. There should be handrails to assist in getting up and space to place wheelchairs at the entrance to change shoes, because the patient's mobility and control are weakened, the sharp points and corners of the home should be blunted and more curves should be used in the design. AD patients are sensitive to light, use intelligent light adjustment system to intelligently adjust the indoor light environment according to the daily outdoor light, and at the same time, to prevent the direct light source will stimulate the patient, the light

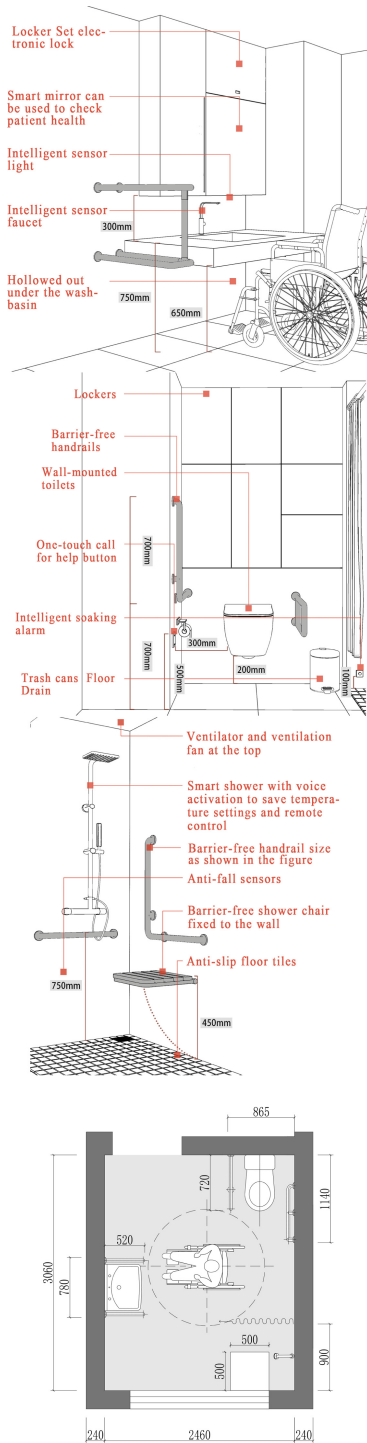


Fig. 5. Bathroom shower accessibility data and overall bathroom floor plan

should take Hidden light trough installation, the ground using matte flooring, control light reflection, reduce the patient's uneasiness about the ground reflection.

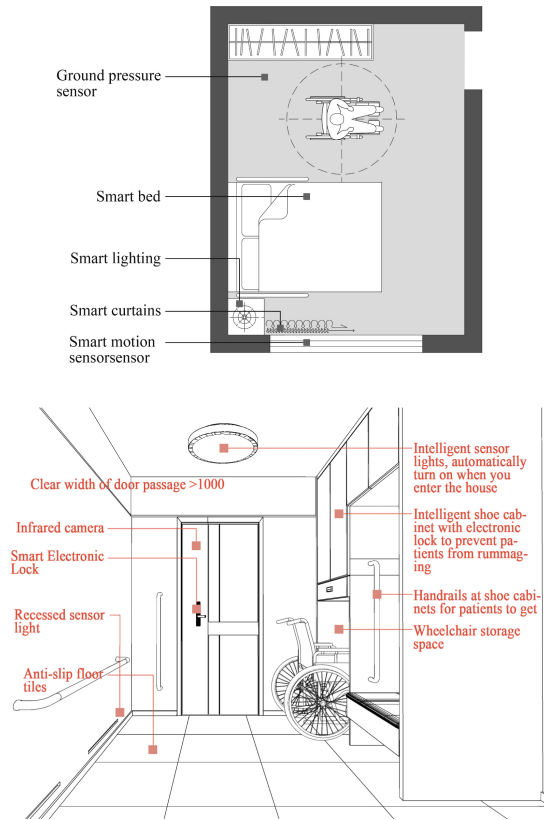
Due to the rapid decline of cognitive function in the middle and late stages of AD patients, patients will become irritable and irritable, and the complicated decoration will become a weapon for patients to attack their caregivers and hurt themselves.

In the bedroom, the barrier-free intelligent sensor bed assists patients to get up and do, both sides are designed with guardrails to prevent patients from falling out of bed while sleeping, health monitoring system will collect ECG information, infrared sensors connected to the caregiver's room, if it senses that the patient gets up at night will promptly remind the caregiver to prevent him/her from being injured or lost; intelligent speakers exercise the patient's communication skills and reduce the patient's loneliness; intelligent curtains help patients to improve the quality of sleep, when the set wake-up time arrives, the outer curtain will be slowly pulled open and the sunlight will illuminate the bedroom through the inner curtain to wake up the patients and prevent them from being stimulated by too strong light, and the curtain will be automatically closed when the patients fall asleep at night; the intelligent lighting system will adjust the indoor color temperature to the most suitable value, and there should be sensor striplight from the living room to the living room to facilitate the patients' activities at night. Considering that AD patients are sensitive to light, in order to prevent the direct light source will stimulate the patients, the lights should be installed with hidden light troughs, so that the light is both bright and not harsh, and the floor uses matte flooring to control the light reflection and reduce the patients' uneasiness about the ground reflection. (Fig. 6).

## 4.2 Nostalgia

*Therapy* Nostalgia therapy is a method of enhancing the cognitive function of AD patients by exposing them to familiar objects to awaken their memories of the past. This method intervenes in three ways by linking audio devices through artificial intelligence technology for treatment: 1. play familiar music or movies, life videos. 2. Loop photos of patients and their families from the past, representative social events with audio commentary. 3. Interact with patients with voice and quiz to enhance memory. [6].

Patients with AD often forget what just happened, but they remember stories from the past. By designing objects that are reminiscent of the patient into the home, we can guide the patient's thinking and slow down the deterioration of the patient's condition. A "memory space" can be designed at the entrance of the house or in the living room to combine the patient's hobbies and special memories, allowing the patient to recall the past events on his or her own, reducing the patient's sense of unfamiliarity with the house and enhancing his or her cognitive thinking. [7].



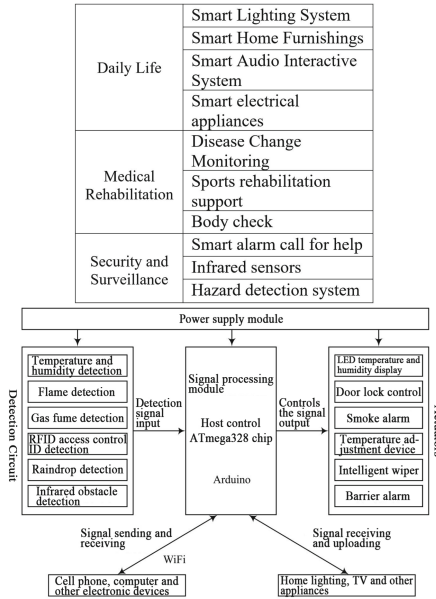
**Fig. 6.** Smart design for entrance barrier accessibility

### 4.3 Smart Home

Overall, the applications of AI in AD patient care can be divided into three main categories, namely, daily life, medical rehabilitation and security monitoring.

In these three categories, the intelligent security system undoubtedly substantially relieves the pressure of caregivers and provides great security for AD patients, for example, in the article “IoT-based intelligent home security monitoring system design design”, the designer used ESP8266WiFi module as a wireless communication module and wrote an APP based on the Android platform (Fig. 7), which mainly performs as follows Remote control is implemented by linking infrared sensors, temperature sensors, smoke sensors and flame sensors and the corresponding household appliances, and when the data collected by the sensors is greater than the safety value, the development board transmits the data to the remote terminal, and the caretaker can realize the control of electrical devices on the APP, thus realizing the safety and protection function [8].





**Fig. 7.** The three main categories in artificial intelligence home care and the overall design of intelligent security systems. Image source: The Design of IoT-based Smart Home Security Monitoring System

### 5 Conclusions

The design of senior housing for AD patients requires consideration of many details, from the barrier-free design and space scale division to the color and material of furniture to ensure the safety and portability of patients’ lives. The addition of smart home products also provides a new way for patients’ health management.

Nowadays, artificial intelligence technology is booming and holds great promise and potential, and the combination of human and intelligent machines will soon become the norm in the life of health and elderly services. Its association with barrier-free design undoubtedly substantially reduces the caregiver’s strain, enhances the patient’s quality of life, brings out the patient’s residual physical functions, improves the patient’s life autonomy, and delays the loss of his or her cognitive functions as much as possible.

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