

Visual Analysis of the Knowledge Graph of Older Adults Smart Furniture Based on Citespace

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Abstract:

With the deepening of the aging of the population, older adults smart furniture has become an important trend in the development of furniture in the future and the new developing direction of health management. Bibliometric methodology and Citespace knowledge mapping were used to summarize the research hotspots, research context, research methodology, topic groups and evolutionary paths of older adults smart furniture. By using the natural splitting point classification method, the research and development process of older adults smart furniture in China can be divided into the initial stage and the rising stage, while in foreign countries, it can be divided into three stages: the germination stage, the starting stage and the climbing stage. The analysis showed that the domestic research hotspot focused on the independent scene of smart furniture, and mostly adopted sensors and other technologies and designs for the furniture subject in different scenes. The research hotspots in foreign countries focused on medical services, health monitoring, and life assistance system research. Wireless sensors, wireless communication technology, and big data information integration are the new trends in its development. In the future, older adults smart furniture in China should promote the development of multi-dimensional systematization, coupling of smart furniture and smart home, and highlight the system adaptation and function type adaptation of the smart aging scene.

Keywords:

Intelligent Furniture, Older Adults, Optimal Aging, Citespace, Smart Home

1. Introduction

As the growing aging process leads to an increased demand for smart products for the older adults. Older adults experience a decline in physiological functions such as vision, hearing, and touch as they aged and are suffering from different physical diseases. And the wisdom pension is one of the effective paths to solve the pension problem. Since 2012, China has begun building smart cities intensively. As one of the most important development directions, the wisdom pension has begun to be

emphasized by many scholars. With the coming of 5G, the smart furniture industry has been further developed. The 5G network can not only meet the extremely fast feedback between people and products through stable and fast network speeds, but also can break the information island about smart furniture. 5G allows smart devices in the home and in society to be interconnected, which brings with it endless possibilities to meet the product needs of older adults in different scenarios [1]. At the same time, with the development and popularization of industrial-grade 3D printing technology, designers can freely define the shape of the product, so that the intelligent furniture can be more compatible with human-machine dimensions and bring more possibilities. The coming of industrial-grade 3D printing technology provides more development space for intelligent furniture [2], which is no longer limited by materials and shapes. It can be applied in more scenes to meet people's comprehensive needs by making furniture intelligent and systematic. Our research adopted Citespace software as one of the visualization methods of the bibliometric method, and by collecting and organizing the related research literature about the field of intelligent furniture both at home and abroad, and then outputting the visualization charts with Citespace software for a deep analysis. Our study provided an effective reference for subsequent scholars by finding out the hotspot changes and development trends of the older adults' intelligent furniture, and hope that designers will pay attention to the real needs of the older adults, and no longer leave the development of products and technology to reject the huge group of older adults. We hope that intelligent products can also better serve the older adults and assist them to live better through different product features.

2. Related Research of Intelligent Furniture for Older Adults

2.1. Data sources

Core journals in Web of Science and CNKI were used as the data support pathway for this study, and relevant literature was retrieved by setting up search topics in the CNKI journal database. The subject keywords included in the search topic were 'smart furniture, older adults, smart home, age-friendly products, age-friendly furniture', etc., and the total number of retrieved documents was 33. One of the earliest pieces of literature related to intelligent furniture for older adults appeared in 2012. In the core collection of Web of Science databases, the search theme conditions that were set using the advanced search formulation included 'Smart homes, Older people, Intelligent' or 'Older people, Home Healthcare, Smart homes' or 'Older people, Smart-home Services' or 'Smart homes, older people' or 'Smart homes, older people' or 'Smart-home Services' or 'Smart homes, older people' or 'Smart homes, older people' or 'Smart homes, older people'. Home Healthcare, Smart homes' or 'older people, Smart-home Services' or 'Smart homes, older people'. After keyword selection was finally organized to get 369 pieces of literature related to intelligent furniture, and the earliest literature research on intelligent furniture appeared in 2000.

2.2. Current status of research in China

After collating the number of published literature on domestic and international research about intelligent furniture for older adults and analyzing it by applying the Natural Split Point Classification Method. The research on Chinese studies about intelligent furniture for older adults can be classified into a starting stage (2012-2017), an ascending stage (2018-2020), and an overall upward trend. The relevant research

directions are also being refined. After combing and studying the literature, we found that there are more research paths in the field of intelligent furniture in China. It involves the intersection of multidisciplinary research in areas such as building science engineering related, light industrial handicrafts, automation technology, industrial economics and macroeconomic management and sustainability, which suggests that the needs of older adults for smart furniture have been further clarified with the depth of the research.

At the starting stage, there is relatively little research literature on intelligent furniture for older adults in China, and many scholars have conducted different explorations of the spatial places for the use of intelligent furniture at this stage. In 2022, Zhenyu Li [3] and Xiaoshan LI [4] proposed the type and design method of smart products applicable in the home care model based on the place of home care population. Hui Zhang [5] took smart kitchens as a background to sort out the inclusiveness of smart kitchen homes from a universal perspective and extended the application of universal design for intelligent furniture. Yimeng Li [6] and Xiaotong Zhang [7] proposed a deeper research on smart kitchen furniture in the direction of interaction design to provide directions and ideas for modern research on intelligent furniture design for older adults. At the starting stage, scholars' research on intelligent furniture for older adults is refined to different application spaces, which are made to be differing according to different use spaces.

In the ascending stage, the research trend of intelligent furniture for older adults has begun to develop into diversification, and more scholars have been attracted to think and pay more attention to the emotional, human-computer interaction, emotional interaction, and the green design of intelligent furniture for older adults. Shulao Liu et al. [8] analyzed the emotional demands of older adults through a case study and proposed a design method to satisfy the emotionalization of older adults. Jiangxiao Li [9] proposed the design principle of age-friendly furniture based on emotional interaction and put forward the prospect of emotional interaction for future age-friendly furniture. Dan Zhao [10] proposed the sustainable design and intelligent design elements and principles of aged home through the home care model. Xiaoyi Chen et al [11] sorted out the medical furniture in the context of intelligence to provide research references for subsequent scholars. The research at this stage pays more attention to the emotional design of the large group of older adults, taking full consideration of the changes in the psychological and emotional needs of older adults in different age groups.

After organizing the technologies adopted for intelligent furniture in domestic papers on intelligent furniture for older adults (Table. 1), it can be seen that the current research on intelligent furniture in China focuses on the study of intelligent furniture in different independent scenes. They are mainly based on spaces such as toilets, kitchens, bedrooms, bathrooms, living rooms, etc., by matching the existing software and hardware equipment, reasonably, to the furniture models in different scenarios, so that they can accomplish some mechanical actions to assist older adults to live better [12,13]. For instance, smart pillboxes, smart toilets, rise-assisted seats, and smart wearables are some of the products. In the application research of intelligent furniture, the realization of intelligent furniture mostly adopts technologies such as sensors and Internet information. However, the current research still lacks correlation and systematic technical support, which leads to the current domestic application of intelligent furniture in life to produce a gap.

Table 1. Intelligent Furniture Technology for Older Adults in China.

	Usage Scene	Furniture type	Software Technology	Hardware Technology	Materials	Researcher
1	toilet	Push-pull handle				Huizi Qi (2019)
2	kitchen	Cabinets Vibration bracelet Auto Off Cooker Intelligent Lifting Hanging Cabinet Floor Cabinet Fall Alarm Intelligent Smoke Sensor Self-disconnect Module Intelligent Flood Alarm Furnace Temperature Detection Alarm Companion Robot	Voice Control System Bluetooth Intelligent Hanging Cabinet Lifting System	Lifting Rods Gas Sensor Static Induction Overload detection Anti-collision, device Current overvoltage Intelligent protection Mechanical touch Open device, infrared sensing Intelligent projection	Fire-resistant board Baked paint board Fireproof board	Ying Yang (2017) Lili Fang (2017) Huizi Qi (2019) Zhenyu Shan (2020)
3	bedroom	Elevated bed panels Closet Smart Pill Box Mattress	Independent temperature control system Automatic on/off button Intelligent LED light	Lifting Rods Pressure and temperature sensors Light Sensors Pressure Sensors Arrays and thermistors		Shulao Liu (2018) Yuanhang Li (2020)
4	bathroom	Intelligent LED light automatic photosensitive switch Intelligent Toilet		Cleaning function Cushion thermostat function Lighting and deodorizing function		Huizi Qi (2019) Lingyue Dai (2021)
5	living room	Massage Chair Booster seat				Xinxin Ma (2020)

2.3. Current status analysis of foreign research

In this paper, we sort out foreign research on intelligent furniture for older adults through a category analysis chart(Figure 1). Foreign intelligent furniture for older adults has a tendency to gradually develop into a combination of multidisciplinary fields, such as biomedicine, ergonomics, remote sensing and so on. In the foreign research on intelligent furniture for older adults, the largest number of papers were

published on the engineering field direction, followed by those on the remote sensing and rehabilitation field directions.



Figure 1. Foreign Category Analysis Chart.

After making and observing the chart of the number of foreign research literature about intelligent furniture for older adults. We found that it can be categorized into three stages, which are germination stage (2000-2008), starting stage (2009-2014), and climbing stage (2015-2020). The overall trend of relevant research on intelligent furniture for older adults in foreign countries shows an upward trend.

We found that the trend of foreign research on intelligent furniture for older adults focuses more on the study of home systems (Table 2), including guardianship systems, rehabilitation systems, and medical monitoring systems, which use a variety of cross-disciplinary technologies. Most of them use wireless sensors and wireless communication technology to monitor and care for the physical health of older adults in a real-time manner. For example, Mei Sun [14] proposed an advisor system (EpiTalk system) for Alzheimer's disease. This system can make appropriate suggestions to older adults in their daily lives through the smart home, as well as assist the cognitively impaired older adults with activities of daily living through in-home therapy.

Table 2. Intelligent Furniture Technology for Older Adults Abroad.

names	research area	technical	goal
Andrew Six smith	Home Monitoring Systems		Independent living
Latfi,Fatiha	Intelligent Environment		Compensating for the loss of cognitive autonomy
Such, MJ	Emotional Engineering		Independent living, emotions
Eklund, J.M.	Home Health and Wellness Systems	Wireless networks, sensors	remote monitoring
Mccann, J	Wearable Computing	computing	Health issues, monitoring and care
Sun, M	EpiTalk Advisor System		daily life
Hensel, BK	Home Telemedicine		Health, medical
Le, XHB	Hospital Information Systems	Sensors, actuators	Medical monitoring
Von Bertoldi, A	Systems for Alzheimer		Medical care
Gaddam, A	Pension monitoring	Wireless sensors	Guardian

	systems	
Bien, ZZ	Complex systems for service integration	Robotics, computational intelligence

2.4. Current status analysis of foreign research

It can be seen in the citespace software co-citation network knowledge map that the reference co-citation map focuses on the same research area over a keyword (Figure. 2). This keyword can be used to indicate the main content of this clustering, and the foreign literature co-citation analysis graph contains prediction algorithms, frail older adults, mobile computing, parkinson disease, monitoring, healthcare, connectivity, aging, and many other directions.

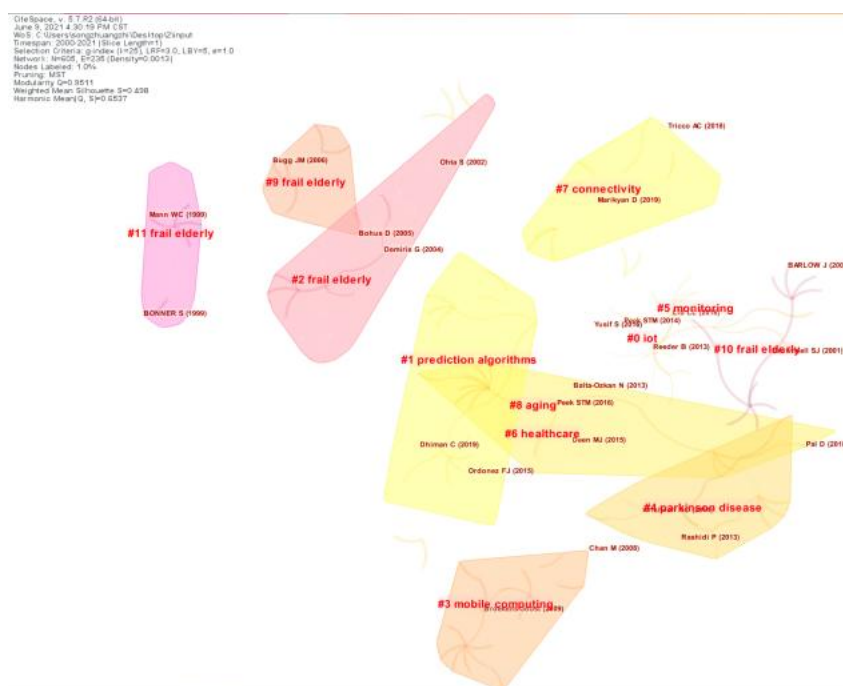


Figure 2. Foreign Literature Cited Reference Analysis Chart.

3. Research Hot Spots and Development Trends

3.1. Analysis of Research Hot Spots and Development Trends of Intelligent Furniture for Older Adults Abroad

We use the keyword co-occurrence analysis function in the citespace knowledge graph software to set up the basis of the software, and get the keyword co-occurrence mapping of foreign older adults' intelligent furniture (Figure 3). The larger the range of the wheel represents the higher the frequency, and vice versa, in which the high-frequency words appearing more than 35 times include: older adults, technology, smart home, health and so on.

In the foreign keyword time zone analysis map (Figure 4), the time of the first appearance of the keyword can be seen. Then, the direction of research development and trends and changes in recent years can be analyzed, as well as the future hotspots of intelligent furniture research can be predicted. The word smart home was first proposed by scholars in 2011, when it was proposed to be more systematic and usable, and then in 2012, when it was turned to the study of smart homes for older adults'

[illegible]

Using the burst terms function in the citespace software, a total of five burst words about foreign intelligent furniture for older adults were screened through the basic settings, which can yield the time and intensity of keyword bursts as well as the span of years in which the keywords appeared. The word Internet has a 3-year mutation cycle from 2019 to 2021 and the highest intensity of 4.22, in addition to ambient assisted living, older adults and other keywords are also relatively high in mutation intensity, respectively, 3.36, 3.04. Meanwhile, keywords that appear with a long year

cycle include ambient assisted living, telemedicine, and independent living. Social networks can be effectively embedded into the structure of smart home environments in older adults' independent living states. It is based on sensors and tools to obtain the crowd connection about the user, and through the implantation of leading-edge electronic technology, it realizes to alleviate the loneliness of older adults with the help of social ways. This makes it easy for older adults to use leading-edge electronic products to communicate and enhance the social experience of older adults, so that leading-edge electronics do not become a technological threshold for their use. After analyzing and combing the highly cited literature related to smart furniture for older adults, the hotspots of foreign research can be roughly summarized into three aspects, including medical services, health monitoring, and assisted living. While focusing on the systematization of intelligent furniture, smart solutions must solve the following issues. (1) ease of use; (2) privacy and security; (3) affordability of the technology in terms of cost; and (4) support for older adults' use and mobility in different environments.

3.2. Research Hot Spots and Trends of Intelligent Furniture for Older Adults in China

The BURST TERMS function in the citespace software was used to screen a total of 2 emergent words about intelligent furniture for older adults in China, with the highest emergent intensity of 2.77 for the empty-nester emergent word, and a lifecycle of 6 years (2016 to 2021). The problem of home care for empty nesters has become more and more obvious in recent years, and the living needs of many empty nesters have not been solved in time. For example, Zhehui Yuan and Shulao Liu [15] summarized and analyzed the bedroom problems of the empty nesters, and then they added intelligent systems to the bedrooms of the empty nesters to make their life better. In addition, the degree of emergence of artificial intelligence reached 2.72. With the rapid development of artificial intelligence, the integrated development of artificial intelligence and intelligent furniture has received the attention of many scholars. Huanping Lei [1] summarized and sorted out after a series of research and analysis, and proposed the future development trend of artificial intelligence and whole-house customization.

It can be found that the domestic smart home for older adults can be mainly categorized into the aspect of artificial intelligence by analyzing the high-frequency words and the highly cited articles corresponding to the emergent words. With the arrival of the 5G era, intelligent furniture can be completely intelligent, and advanced technology can be used in intelligent furniture to realize the various needs of users. In the future smart homes for older adults based on artificial intelligence will be a new trend for future research.

4. Results and Discussion

In this paper, we pulse and compare the research on intelligent furniture for older adults both domestically and abroad through the citespace visualization and analysis software, and come up with the following four conclusions:

(1) The research on intelligent furniture for older adults in China can be divided into two stages: starting and rising through sorting out and analyzing the existing research literature on intelligent furniture for older adults. Domestic intelligent furniture research involves multi-disciplinary fields, such as building science and engineering,

light industry handicrafts, automation technology, industrial economy and macroeconomic management and sustainable areas, etc., the research is still in the early stages of figuring out. With the development of the aging trend and the popularization of healthy aging policies for older adults, the development of intelligence provides a broader future for intelligent furniture for older adults, and shows a stronger potential under the intersection of multiple disciplines.

(2) According to the emergent word of intelligent furniture for older adults both domestically and abroad, “intelligent furniture” was first proposed in 2011 and began to receive widespread attention in 2012. There is a growing focus on how smart furniture can monitor the physiological and psychological state of its inhabitants and be an intervention to improve well-being. Scholars are exploring innovative and creative solutions to the problem of diversity and complexity of the existing digital divide in older adults, including modifying the design process, developing tools, and iterating the design methodology.

(3) According to the content of research, there is a growing trend of research on topics such as empty nesters, frail older adults, Parkinson's, and environmentally assisted living. Researchers are actively exploring the adaptability and realizability of intelligent furniture for different user profiles, complex lifestyles and human-environment interactions of older adults under differentiation. It also involves enhancing cooperation with the artificial intelligence field in order to find a way to develop technologies that provide valuable support for human life and well-being.

(4) From the viewpoint of research trends, the development of intelligent furniture for older adults, as one of the important strategies for healthy pension, is affected by the common influence of hardware, security, system integration. Today, the whole of domestic smart home is showing an upward trend. Wireless sensors, wireless communication technology is the new trend of its development, and the monitoring of health indicators may become the new direction of future furniture design. Domestically, the research segment is based on intelligent furniture in independent scenes, mostly using sensors and other technologies, and proposing design requirements for the needs of different scenes to continuously improve the quality of life of older adults. Within this context, research on individual users' capabilities, cognitive thinking and their necessary functional requirements and preferred interaction modes for supporting their use of preferred interactive devices as well as facilitating the feasibility and user experience of smart furniture has become a hot topic. The smart home in the context of the Internet of Everything and home system integration of the IOT intelligence, and combined intelligence has become a development trend.

5. Conclusions

Smart information technology and assisted living services for older adults have been proven to significantly reduce the negative impacts of population ageing. After combing domestic and foreign research on intelligent furniture for older adults, it can be found that domestic research is still in the exploratory stage, even though it shows a growing trend. The solutions proposed by relevant research theories and practices in the future should follow an omnidirectional and multidimensional approach to improve the quality of life and well-being of older adults. With the domestic furniture manufacturing industry, the development of intelligent interactive applications and the digital transformation of pension services, the demand for intelligent products for

older adults is increasing, the application scene of intelligent pension is also expanding, the field of intelligent furniture is shifting from ‘focusing on technology’ to ‘shaping the scene’ so the future of intelligent furniture for older adults has a lot of potential for development. At the same time, the problem of the digital divide among older adults exists objectively and is unavoidable, and needs to be widely emphasized by the academic community. All designs should be based on the principle of empowering older adults, bridging the digital divide by exploring the inclusive design tools of smart functions, and promoting the successful development of intelligent furniture for older adults and more dignified life for older adults.

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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