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Research Article

Research on the Design of Accompanying Products for the Mentally Retarded Elderly Based on AHP

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As the number of elderly patients with dementia is increasing year by year, accompanying products for the elderly with dementia are becoming more and more important. Senile dementia has become a major disease that affects countries around the world and, at the same time, it has brought enormous pressure on social care. Therefore, this research aims to obtain a new set of design methods for dementia elderly care products by introducing the combination of AHP and fuzzy evaluation methods and applying them to design examples. And then break through the existing design path of accompanying products for the elderly with dementia, and relieve the social burden. This study takes the intelligent care robot for the elderly with dementia as an example. Due to the particularity of user groups, this article proposed a design method for elderly care products that integrates mathematical theoretical models. This design method is convenient for designers to have a more accurate data reference when designing and positioning, and summarizing the supporting product design scheme that can better meet the actual needs of the elderly with dementia. Through SET factors to analyze the driving force of demand for dementia elderly care products, and combined with a questionnaire survey to establish the design requirements of dementia elderly care products for analysis of hierarchy process, it effectively defines the design demand attributes of dementia elderly intelligent care robots. The research results are applied to the design of the intelligent accompanying care robot for the demented elderly, the comprehensive fuzzy evaluation of the design scheme is carried out, and the direction of further optimization of the scheme is obtained. This article proposed a design method for accompanying care products for the elderly with dementia by combining F-AHP (Fuzzy Comprehensive Evaluation Method and Analytic Hierarchy Process). This design method is based on a rigorous mathematical theoretical model. Compared with the traditional design method, this research focused on quantitative analysis and evaluation of the actual design requirements of the dementia elderly care products and had more accurate design priority data reference in the scheme design. The research results show that based on the combination of F-AHP, this article redefines the design path of accompanying products for the elderly with dementia, and concludes that the functions that need to be improved and optimized in the future of intelligent accompanying robots for the elderly with dementia are mainly: executive ability training, computing ability training, and observation ability training. At the same time, the design process of the intelligent escort robot for the elderly with dementia can also be applied to the design of intelligent elderly products, which can improve the service experience of intelligent elderly products in a targeted manner.

1. Introduction

The 21st century is an era of population aging, with the number of people suffering from various chronic diseases, including dementia [1], increasing at an average rate of one new dementia patient every 3 s worldwide, and the trend continues to grow [2]. The cognition and social psychology of patients decline with age, and it can be seen that the incidence rate is directly related to age [3]. Therefore, "dementia elderly" has received extensive attention from society [4], and senile dementia has become a public health problem in countries around the world. The care of the elderly with dementia puts a more severe burden on the consideration and balance between family, work, and care.

Therefore, in order to reduce the social pressure and burden of old age care, research on the elderly with dementia has become one of the key issues of international social research. There are different degrees of research in various fields, but most of them are currently concentrated in the fields of medicine and sociology.

Dementia research in the international community is mainly in the fields of medicine and sociology [5]. However, with the continuous development of technology and the demand for compound talents, the development of cross-integration among various fields has become a trend, and the design discipline has a very strong characteristic of cross-integration. Design is an indispensable discipline in social development. As far as industrial design is concerned, it can promote the continuous development and innovation of our society. Excellent design works can bring happiness and convenience to people's lives. There are also designer contributions everywhere. At the same time, the discipline of design is also an interdisciplinary discipline, which can integrate medicine, sociology, and various scientific and technological achievements, and provide new research ideas and methods for solving some social problems under the background of discipline integration. Therefore, from the perspective of the field of design, a design research method that is in line with the elderly with dementia is proposed to reduce a certain burden for the society. Through clear research data, designers can provide accurate design references to determine the key direction of design. Based on this understanding, this study from the perspective of design, based on the research in the fields of medicine and sociology, combined with F-AHP, proposes a new set of design optimization and innovation methods for elderly care products. And then designing the accompanying products that can really help the elderly with dementia, and improve the life services for the elderly with dementia [6]. At the same time, at a certain level, the design path of elderly care products has been broadened for designers to refer to when designing elderly care products.

In recent years, the elderly with dementia have also become the focus of designers or scholars. For example, Zhou and Li and others proposed a space environment design with healing characteristics, which mainly meets the special needs of the elderly with dementia [7]. Guo proposed to integrate the product functions of music therapy in the process of product design, such as combining with percussion games, to study the emotional nature of product interaction, and the care of elderly patients with dementia [8]. Cao and Chen proposed to use daily necessities as a carrier to design the process of interventional assisted care, and implant technology and nondrug interventions into it, summarizing the key points of the possibility of designing interventions [9]. Yang and Wang proposed that elderly patients provide one-stop services, including functional modules such as online medical treatment, shopping system, and user center, to meet the diverse needs of users [10]. We can find that most of its designers or scholars discuss more design results and design orientation, or just unilaterally discuss the research process of using design to intervene in the elderly with dementia. In other words, it is more to propose a research methodology related to the design of dementia elderly from a qualitative point of view, and there is a lack of data comparison and analysis of quantitative research. For example, design problem insights, competitive product analysis, user portraits, user journey maps, SWOT analysis, storyboards, brainstorming, and other design methods, but the careful study found that they all lack quantitative research-based data comparison and analysis. For the design of accompanying products for the elderly with dementia, it is impossible to accurately obtain the actual needs of the users themselves through qualitative research methods, because the elderly with dementia, as a special group, cannot have normal language communication and brain awareness. Therefore, this article attempts to propose a new set of design methods for dementia elderly care products based on quantitative research, based on medical and sociological research, combined with qualitative research methods. The main purpose of this study is to discuss the new design path of accompanying products for the elderly with dementia, relieve the burden of the elderly with dementia on their families and medical staff, and design accompanying products for the elderly with dementia that is more in line with their actual needs. SET factors were used to analyze the drivers of demand for companion products for the elderly with dementia, and then the hierarchical analysis was used to analyze the importance and priority of demand for the design of companion products for the elderly with dementia; the design was applied to the design of an intelligent companion robot for the elderly with dementia, and the fuzzy evaluation method was used to evaluate the design solution and identify directions for further optimization. This study firstly reviewed the research on the elderly with dementia from different perspectives by many scholars in recent years; then briefly introduced the rules of the SET factor analysis method, and carried out the design of the questionnaire, as well as the distribution and collection of the questionnaire; third, through the collection of questionnaire data, a hierarchical structure model of design needs are established, and the importance and priority of design elements of dementia elderly care products are obtained; fourth, the results are applied to the case design of the intelligent escort robot for the elderly with dementia, and a comprehensive fuzzy evaluation of the scheme is carried out. Finally, some conclusions and optimization suggestions are given by discussing and comparing with other existing methods.

2. Literature Review

Different fields of research on the elderly with dementia have different focuses. The field of medicine focuses on drug and nonpharmacological treatments, the field of sociology focuses on humanistic care and social care, and the field of design focuses on living environments, life care products, and design principles for people with dementia. To fully understand the behavior of the elderly with dementia and the actual needs of users, it is necessary to understand the current research on the elderly with dementia by scholars in various fields. Therefore, this article mainly reviews some

research of related scholars in the fields of medicine, sociology, and design in recent years, which are closely related to the research of this article.

2.1. Part of Research on Dementia in the Medical Field. Dementia has always been a major focus of research in the medical field, and many scholars have pointed out in their studies that traditional medication can have significant side effects on dementia patients, whereas nonpharmacological treatments are not only more effective in treating dementia patients but can also avoid some of the dangers associated with medication. For example, in "Combining music and reminiscence therapy interventions for well-being in elderly populations" [11]: a systematic review, Istvandity and Lauren noted that music therapy and nostalgia therapy could be used as an alternative to medication to a certain extent and had a positive effect on the participants' physical and psychological well-being. This study demonstrates the benefits of nonpharmacological treatments for people with dementia, as it shows that music therapy and reminiscence therapy can be used to replace medication to some extent, have a positive effect on the participants' physical and mental health, and increase their sense of well-being. In the research on the rehabilitation treatment of patients with dementia, Gu et al. put forward their views in "The effect of integrating nursing home care with medical rehabilitation for patients with senile dementia" [12]. Through systematic and continuous medical care combined with rehabilitation training, the cognitive function, activities of daily living, and quality of life of patients with early and midterm dementia can be significantly improved, and the further development of the disease can be slowed down. It can be seen that the combination of medical care and rehabilitation training is particularly important for the treatment of dementia patients. In addition, Li et al. discussed the improvement of sleep disorders in patients with dementia through light therapy in the article "Light therapy on improving sleep disorders in patients with Alzheimer's disease: a systematic review" [13]. In the research of these scholars, we can find that one of the ways to have better treatment and rehabilitation effects for patients with dementia is through nondrug treatment, which not only does not bring fear of drugs to patients but also makes patients produce a relaxed mood. At the same time, some scholars have pointed out that rehabilitation physiotherapy for patients with dementia needs to be based on a combination of medical care and nursing, which is more conducive to the recovery of patients. Therefore, nondrug therapy and rehabilitation physiotherapy have become important research contents in the treatment of dementia patients in recent years.

2.2. Part of Dementia Research in Sociology. Dementia is not only one of the main focuses of academic research in the medical field, but also the care of elderly people with dementia has always been inseparable from society. In the field of sociology, it is also one of the main concerns of scholars. For example, Lee and Wang in the article "Preliminary development of humanistic care indicators for the resident in nursing homes" [14], used experiments to verify humanistic holistic care, addressing the unmet care needs of older people with dementia can promote independence and reduce loneliness. Therefore, it can effectively relieve the emotions of patients with dementia, further slowdown the development of their disease, and reduce the burden of care for society. Zhou and Li and other scholars put forward their views in the article "Consensus statement on the neurocognitive outcomes for early detection of mild cognitive impairment and Alzheimer dementia from the Chinese Neuropsychological Normative (CN-NORM) Project" [15]. For patients with early dementia, dementia care should aim to maintain or promote the independent ability of patients, and provide caregivers with cognitive intervention methods and scientific and reasonable care to delay the development of the disease. Hatch pointed out in the article "Adaptation to aging in life course perspective" [16] that the mental health of the elderly is worrying. The decline in self-care ability and the weakening of social relationships caused by dementia are the main factors that negatively affect the mental health of the elderly. Secondly, the death of a partner will also cause psychological stress and negative emotions in the elderly. Therefore, special attention should be paid to the mental health of the elderly with dementia to avoid many negative emotions. In the article "The positive aspects of caregiving by caregivers of senile dementia patients living in the community and the influencing factors" [17], Liu et al. proposed that the community should guide the care of the elderly with dementia so that patients with dementia can receive more professional care. It can also make caregivers have a better state of mind, thereby reducing the psychological burden and social pension pressure of the caregivers of the elderly with dementia. Through these studies, we can know that patients with dementia need more social care, always pay attention to their mental health of patients, and try to avoid bringing some negative emotions and psychological burdens to patients. Therefore, alleviating the condition of dementia patients requires more care and tolerance from all walks of life, especially their mental health and personal emotions.

2.3. Part of Research on Elderly Care Products in the Field of Design. In the field of design, whether it is industrial design, architectural design, or other related designs, the design around the elderly has always been the focus of designers and scholars. Men et al. put forward their views in the article "Product design of caring the elderly from the perspective of new media" [18]. Apply new media to product design for caring for the elderly, analyze the emotions of the elderly, and conduct design research from the direction of humanized design and emotional design. Therefore, combined with the application of new media in the design of elderly products, it is possible to better explore the operation habits, cognitive methods, and potential human-computer interaction of the elderly. Xiang and Wang put forward a new path to analyze the application of intelligent escort products from three aspects in the article "Intelligent accompanying: a new path for mental health management of the elderly" [19].

These three aspects include the actual needs of the product, the limitations of traditional nursing, and the technological development trend that promotes the birth of intelligent escort. Pickle et al. proposed the design of intelligent escort products for the elderly based on user experience in the article "Research on home-based care intelligent products design based on user experience published" [20]. User experience is one of the important criteria for judging the quality of a product. Therefore, for the elderly group with relatively weak learning ability and understanding ability, the user experience of intelligent escort products for the elderly is more important. In terms of geriatric care product design, Qi and Zhou in their article "A user study of wearable product for elderly care-taking community nursing service as example" [21] proposed to analyze the actual needs of elderly care and the user needs of wearable products, to provide design methods and guiding principles for wearable product designers. In the design of intelligent escort robots, Lehto pointed out the method in the article " Robots with and for the elderly people - a case study based on action research" [22]. For the development and research of elderly care robots through action research and live experiment methods, use technology to develop new digital health and welfare services for the elderly to promote the physical and mental health of the elderly, and design services and products that meet the needs of the elderly. In their article "Research on the design of service system of nursing robot for the elderly" [23], Wang and Yuan proposed to integrate service thinking into the research of elderly companion products to keep pace with users' lifestyles and enhance the utility of the products to meet their diverse needs. In terms of the styling design of elderly escort products, Bi and Wang argue in their article "Research on the styling design of elderly escort robots" [24] that the styling design of elderly intelligent escort robots can express humanistic care, and from the perspective of users' emotional needs, their styling design reflects emotional characteristics. In the article "Research on the design of companion interactive products based on the group of empty nesters" [25], Jin and Teng designed the interactive functions of the products based on interaction technology and designed the appearance and interactive interface of the companion interactive products according to the behavioral characteristics of the elderly. From the research of these scholars, we can know that for the design of elderly care products, it is first necessary to effectively analyze the actual needs of the elderly, and second, the behavioral interaction habits and psychological emotions of the elderly need to be considered in product design, and humanistic care should be highlighted. Finally, the design of elderly care products should take the perspective of user service as the starting point to provide a good service experience for the elderly.

3. Information Modeling of Design Requirements

Design demand analysis of care products for elderly families with dementia is a preliminary study of user-centered product design, which mainly analyzes the design demand of care products for elderly families with dementia from the two aspects of the user environmental factors and user needs. In terms of environmental factors, SET factor analysis was used to analyze the driving force of design demand of care products from three levels of the social environment [26], economic environment, and technical environment, and to indicate the direction of design demand of care products. In terms of users' needs, it investigates the lifestyle of elderly people with dementia, excavates users' needs, and then finds design opportunities.

3.1. Driver Analysis of Product Design. SET factors were used to analyze the driving force of demand for care products for the elderly with dementia, and to find out the opportunity gap of care products for the elderly with dementia. And determine the potential demand of products in the new era and new form, enhance the innovation of products and improve the spatial optimization of existing escort products.

3.1.1. SET Factor Analysis of Care Products for the Elderly with Dementia

(1) Analysis of factors of social trends of products. In terms of social trend factors, in the family of elderly with dementia, dementia not only has an impact on the physical and mental health of the elderly, but also has an impact on the work and life of family care staff, and then produces a series of contradictory problems. Therefore, the role and carrying function of care products will also change and need to be more inclusive in many aspects. The value of care products is not only reflected in the needs of patients themselves, but also in a fusion of family and social needs.

(2) Analysis of economic driving factors of products. In the 21st century, China's economy continues to grow, and people's income level and power of consumption have increased significantly, care products gradually in the elderly family life. To a certain extent, it makes up for the work pressure of social services, reduces the economic burden of long-term loss, and saves the economic cost of employing care personnel.

(3) Analysis of technical development factors of products. Technological development factors mainly in 5G technology, Internet of Things, cloud computing, big data, and other technical aspects provide strong technical support for the research of elderly products. The current intelligent technology can be applied to home care products to improve the quality and effectiveness of care.

3.1.2. Opportunity Gap of Care Products for the Elderly with Dementia. Through SET factor analysis, it can be seen that the interaction between society, economy, and technology has brought two product opportunity gaps for dementia care. On the one hand, the average national standard of living is getting higher and people's mindset is becoming more progressive,

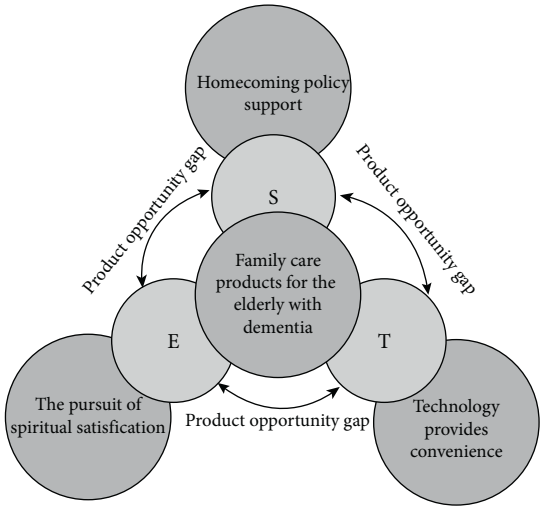

Figure 1: Analysis of the product opportunity gap in SET mode.

which in turn influences the way people live, care for the elderly with dementia will be driven toward more scientific, effective, dignified, and other needs. At the same time, the development of society and technological innovations have led to a gradual increase in the number of intelligent products in the home, as mankind continues to adapt to technology and enjoy the convenience that technological advances have brought to all aspects of life. On the other hand, China's social culture is influenced by Confucian culture, and the care of elderly patients is mainly family care. Meanwhile, the accelerated urbanization process and the competition of occupational pressure have accelerated the pace of life of the young generation, and they are unable to care for the sick elderly. Therefore, social trends, economic dynamics, and technological development (shown in Figure 1) have created a product opportunity gap to address the balance between dementia care and work-family care, difficulties in life care, and provide efficient and convenient care.

3.2. User Requirements Analysis. Through the analysis of the social environment, economic environment, and technical environment of the family care products for the elderly with dementia, the change of SET factors affects people's lifestyles. Social trends, economic dynamics, and technological changes have led to changes in people's understanding of values and emotions. The value is reflected in the design of products to solve important problems, not only to meet the needs of users but also for the long-term survival of human society friendly and improve social responsibility. Emotion is reflected in the increase of human attention to emotional needs, from the full material needs to emotional needs. The way of life of human beings is affected by emotion, values, and morality. Under the influence of society, economy, and technology, some new demands are generated. Therefore, the lifestyle of the elderly with dementia is investigated.

3.2.1. User Interview. The user interview is the most direct and effective method of understanding patients. Based on the preliminary desktop survey and the gap in product opportunity identified by the SET factor analysis, the author has a preliminary understanding of the direction of the research of care products for elderly families with dementia, which can be flexible depending on the actual situation in the interview. The user group of this study is mild to moderate elderly patients between 55 and 70 years of age. Person-to-person interviews are conducted on 12 subjects, including 7 family members, 2 doctors, and 3 patients with mild dementia who have self-reporting ability. Through the summary of the interview records, three aspects can be obtained. First, patients have a certain degree of negative attitude toward life, and feel useless for their failure in life and positive social entertainment has a certain impact on the elderly. Second, the patient's spiritual life is relatively lacking, the elderly usually only through TV, chess, and walking as entertainment activities in daily life. Third, there is currently a lack of training in cognitive interventions for the elderly at home, and cognitive interventions for patients may play an important role in slowing the progression of disease in the elderly.

3.2.2. Questionnaire Survey. According to the user interview, further, determine the specific questions of the survey questionnaire. This questionnaire mainly investigated the living patterns of patients with mild to moderate symptoms from the aspects of basic information, daily life performance, pain points, and expectations of caregivers. A total of 200 questionnaires were distributed, of which 160 were valid. The subjects of the questionnaires were family members of the patients. Due to the limited offline user group, the author searched online groups through Zhihu and public accounts to find communication groups related to dementia and distributed questionnaires in communication groups, including WeChat groups and QQ groups.

3.3. Summary of User Requirements. The results of interviews and questionnaires with family members, patients, and doctors were analyzed. At the same time, combined with the previous desktop research, the characteristics of the elderly population with dementia were analyzed. User needs can be integrated into four categories, which are life rehabilitation needs, emotional needs, ease of use needs, and support needs.

4. Methodology

This research mainly determines the key direction of the design by analyzing the design requirements of the dementia elderly care products. Compared with most common product design methods, most designs are from the perspective of users or designers, and design solutions can be obtained through communication with users or questionnaires. The research object of this article belongs to a special group, and the elderly with dementia lack the same thinking and awareness as ordinary users. Therefore, designers cannot directly draw design plans through survey questionnaires and qualitative analysis methods and need to

assist design decisions through systematic data analysis. This article mainly uses hierarchical analysis and fuzzy evaluation method together and applies the results to the design decision of companion products for the elderly with dementia, which can better avoid the importance of ignoring the actual needs of the elderly with dementia due to the subjective evaluation of designers. When calculating the weighting of each requirement separately, the design priority is clear at a glance. This method can mathematical and systematize the thinking process of designers, which is easy to solve the multilevel, multicriteria, and difficult to quantify product design requirements for dementia elderly care products, and can be applied to other elderly product designs.

4.1. Analytical Hierarchy Process (AHP). AHP is a method of quantitative analysis of qualitative problems [27]. The method is to disassemble the problems and then cluster the analysis to obtain the hierarchical model with a clear structure, and then provide decision-makers with the basis for weight calculation. The research process is shown in Figure 2. The design of care products for families of elderly people with dementia is aimed at elderly people with disease characteristics, which are characterized by polymorphism and complexity in the investigation and analysis of user needs. Therefore, quantitative analysis is particularly important and suitable for this study.

4.2. Fuzzy Analytic Hierarchy Technique. The fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. The concept of fuzzy sets was developed in 1965 by the American automatic control expert L. Chad. A. Professor Zadeh proposed to express the uncertainty of things. The comprehensive evaluation method transforms qualitative evaluation into quantitative evaluation according to the membership theory of fuzzy mathematics, that is, uses fuzzy mathematics to make a general evaluation of things or objects that are constrained by various factors. It has the characteristics of clear results and powerful systematicness, which can better solve vague and difficult-to-quantify problems, and is suitable for the solution of various non-deterministic problems. For the sake of description, according to the basic concepts of fuzzy mathematics, the relevant terms in the fuzzy comprehensive evaluation method are defined as follows.

(1) Evaluation factor (Y) refers to the specific content of the sublevel demand review.

(2) Evaluation factor value (V) refers to the specific value of the evaluation factor.

(3) Weight (W) refers to the status and importance of the evaluation factor.

(4) Evaluation vector (B) refers to the target demand evaluation vector calculated by the formula.

(5) Fuzzy evaluation matrix (R) refers to the matrix of evaluation data results.

(6) Comprehensive evaluation value (U) refers to the sum of the weighted average evaluation values of the same level of evaluation factors.

4.3. User Demand Hierarchy Model Building. Combined with the characteristics of elderly patients with dementia and other aspects of comprehensive analysis and research, the needs of companion product design were divided into target level, criterion level, and sub-criterion level, to create a hierarchical model of the needs of companion product design for elderly families with dementia. User needs for companionship products for families with elderly people with dementia analysis as a target layer G. Four kinds of design index elements, such as rehabilitation needs, emotional needs, ease of demand, and support requirements are used as the criterion layer. Sixteen perceptual words were extracted from the user needs of escort products, summarized, and sorted out in the early stage as the subcriterion layer. The specific hierarchical model is shown in Figure 3.

4.4. Construction of Judgment Matrix and Weight Determination. The construction of the judgment matrix is shown in Table 1. The importance of each element can be quantified in Table 2, and then the nine-point scale is used for comparison.

To meet the design requirements of the target tier and to pass the consistency test, firstly, 30 people were randomly selected to score the level of requirements. These included teachers of design professionals, design staff, patients' families, and doctors. Secondly, they were assigned values according to the matrix scale in Table 2 values. Finally, the comparison matrix model is constructed through Tables 3 to 7 to calculate the eigenvector and weight value.

To ensure the scientificity and standardization of the evaluation, it is necessary to conduct a consistency test on the evaluation results. See formula (1) for the calculated consistency index and formula (2) for the calculated consistency ratio:

$$\mathrm{CI} = \frac{\lambda\max - n}{n - 1}, \tag{1}$$

$$\mathrm{CR} = \frac{\mathrm{CI}}{\mathrm{RI}}. \tag{2}$$

Find the average random consistency index RI with the values shown in Table 8. When $\mathrm{CR} \le 0.1$, the consistency test is deemed acceptable, Otherwise, the judgment matrix needs to be modified. The results of the consistency test are shown in Table 9.

4.5. User Needs Hierarchy Calculation Ranking. After the analytic hierarchy Process (AHP) calculation, $\mathrm{CR} \le 0.1$, and the consistency test was passed. The criteria were sorted as follows: rehabilitation needs > support needs > ease of use needs > emotional needs, indicating that rehabilitation repair needs and support needs are more important. The order of importance of rehabilitation demand factors was memory training > perform competency training > observation skills

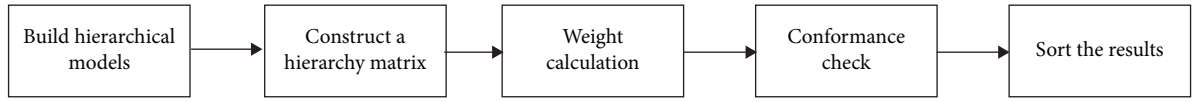

Figure 2: Phases of methodology.

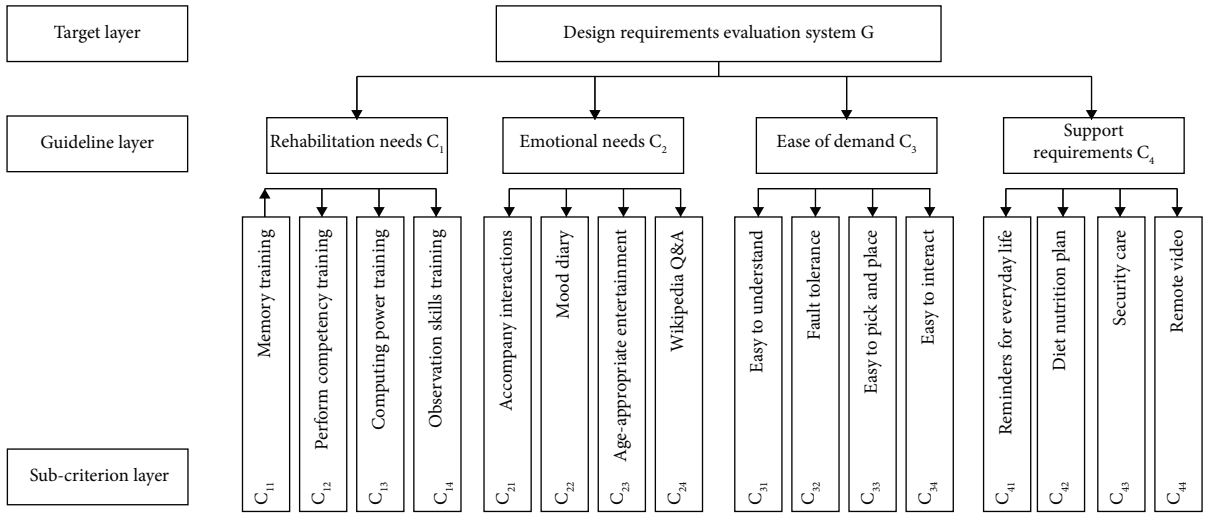

Figure 3: User requirements hierarchy model.

Table 1: Construction of judgment matrix.

X	Y_1	Y_2	...	Y_n
Y_1	Y_{11}	Y_{12}	...	Y_{1n}
Y_2	Y_{21}	Y_{22}	...	Y_{2n}
...	...	...		...
Y_n	Y_{n1}	Y_{n2}	...	Y_{nn}

training > computing power training, indicating that the intervention of memory and perform competency training was more important in rehabilitation demand factors. The order of importance of support demand factors was daily life reminder > safety care > remote video > diet and nutrition plan, indicating that daily life reminder and safety care were more important in support demand factors. In the important order of ease of use demand factor layer, easy to interact > fault tolerance > easy to understand > easy to remove and put. In the order of importance of the emotional needs factor layer, they are: companion interaction > entertainment activities for the aged > encyclopedia > mood diary. The overall weight order of needs is shown in Table 10.

An in-depth analysis of the requirements for the design of home care products for the elderly with dementia using hierarchical analysis shows that the rehabilitation needs have the greatest influence on the design of care products for the elderly with a weighting of 0.3908, while the support needs, ease of use needs, and emotional needs are ranked in order of importance. At the sub-criterion level indicator rating $C_{11} > C_{41} > C_{43} > C_{12} > C_{34} > C_{21} > C_{44} > C_{14} > C_{23} > C_{32} > C_{13} > C_{42} > C_{31} > C_{24} > C_{33} > C_{22}$.

Under the guidance of data analysis science, the design of dementia elderly care products should pay more attention to its rehabilitation training, especially at the level of memory training, followed by daily life reminders and safety care functions at the support level.

5. Application Examples

5.1. Design and Practice of Intelligent Escort Robot for the Elderly with Dementia. Through further research on the functional requirements of companion care products for the elderly with dementia, the weight analysis results of the design elements of accompanying care products for the elderly with dementia are used as an important design basis. Combined with design practice [28], an intelligent companion nursing robot is designed for the elderly with dementia, which can be used at home to meet the various needs of the elderly with dementia [29]. The core of the design is to help the elderly with dementia regain confidence in their lives through external interventions [30], with the rehabilitation and support needs of the elderly with dementia as the main function, and the addition of emotional needs and ease of use as supplementary functions for the elderly with dementia. In addition, the design avoids complex shapes, bright colors, and hard materials.

5.2. Design Effects and Functions of the Intelligent Escort Robot. The design renderings of the intelligent escort robot for the elderly with dementia are shown in Figure 4.

5.3. Application of the Actual Needs of the Elderly with Dementia in the Design. Based on the existing artificial intelligence technology, according to the actual needs of dementia elderly care, intelligent rehabilitation training, intelligent life support, intelligent safety protection, intelligent spiritual companionship, and intelligent interaction

Table 2: Judgment matrix scale table.

Scale	Meaning
1	Indicates that two factors are equally important compared to each other
3	Indicates that the former is slightly more important than the latter when compared to the two factors
5	Indicates that the former is significantly more important than the latter when compared to the two factors
7	Indicates that the former is more strongly important than the latter when compared to the two factors
9	Indicates that the former is more extremely important than the latter when compared to the two factors
2, 4, 6, 8	Median of the above two adjacent judgments
Inverse	Judgment Y_{ij} for comparison of factor i with j, then judgment $Y_{ji} = 1/Y_{ij}$ for comparison of factor j with i

Table 3: Judgment matrix and weight of target layer.

G	G_1	G_2	G_3	G_4	W
C_1	1	2	2	2	0.3908
C_2	1/2	1	1	1/3	0.1460
C_3	1/2	1	1	1/2	0.1584
C_4	1/2	3	2	1	0.3048

Figure 4: Design renderings.

are carried out in the design and practice of intelligent nursing robot for the elderly with dementia. The specific structure is shown in Figure 5.

(1) Intelligent rehabilitation training system: the intelligent rehabilitation training system includes memory training, performing competency training, and observation training. It mainly helps the elderly with dementia to exercise their cognitive abilities, and the specific needs are as shown in C_{11}~C_{14}.

(2) Intelligent life support system: the intelligent life support system includes daily life reminders, diet, and nutrition plan. In daily life, it mainly provides reminders to take medicine, exercise, anniversaries, and important trips through intelligent AI technology. In terms of diet and nutrition plans, we can reasonably plan three healthy meals a day according to the health status of the elderly, and support the cloud ordering system. In addition, the humidifier is also integrated into the design scheme, which can better create a comfortable environment for the elderly. Specific requirements are as shown in C_{41} and C_{42}.

(3) Intelligent safety protection system: the intelligent safety protection system includes security monitoring, one-button call for help, remote control, and other functions, which can effectively guarantee the life safety of the elderly with dementia at home to provide timely assistance. The specific requirements are as C_{43}~C_{44}.

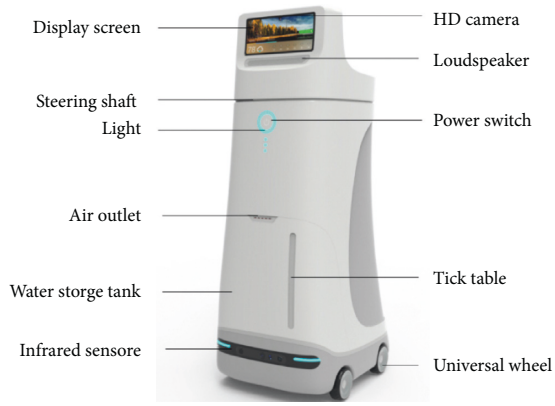

Figure 5: Design a function diagram.

(4) Intelligent spiritual companion system: the intelligent spiritual companion system includes interactive companionship, AI language, chat, video and audio, entertainment activities, intelligent questions and answers, and other functions, which can provide certain spiritual comfort to the elderly with dementia. The specific needs of C_{21}~C_{24}.

(5) Intelligent interactive system: the intelligent interactive system includes voice interaction and gesture interaction. Automatic navigation and voice interaction can help the elderly with dementia use more conveniently when they are unable to move or operate complex operations. Meet the actual interaction requirements of the elderly with dementia, such as $C_{31} \sim C_{34}$.

5.4. Fuzzy Comprehensive Evaluation. To conduct a comprehensive evaluation of the design scheme, a total of 20 evaluators including product designers, geriatric medical experts, and geriatric product researchers from relevant enterprises were invited. The specific evaluation process is as follows:

(1) Experts give evaluation opinions to determine evaluation elements, using $Y = \{y_1, y_2, y_3, y_4\}$ represents the need for rehabilitation, the need for feeling, the need for ease of use, and the need for

support, respectively, and the evaluation element set is determined as $Y_i = \{y_{ij}\}$ $(I, j = 1, 2, 3, 4)$.

(2) Determine the rating of comments and their corresponding standards, set as $V = (v_1, v_2, v_3, v_4, v_5)$, respectively, corresponding to V = (very excellent, excellent, average, poor, very poor), where the corresponding score is: 95 points for very excellent, 80 points for excellent, 60 points for average, 50 points for poor, and 40 points for very poor.

(3) Calculate the values in each judgment matrix (Tables 3–7) and get the weight vectors of each level, as follows:

Target level: $W_1 = (0.3908, 0.1460, 0.1584, 0.3048)$
Rehabilitation needs: $W_2 = (0.5426, 0.2359, 0.0995, 0.1221)$
Emotional needs: $W_3 = (0.4491, 0.0775, 0.3181, 0.1553)$
Ease of use requirements: $W_4 = (0.1681, 0.2683, 0.0947, 0.4688)$
Support needs: $W_5 = (0.4015, 0.0939, 0.3212, 0.1834)$

(4) The mathematical model is used for comprehensive evaluation. The weight vector W and the corresponding fuzzy evaluation matrix R are, respectively, used for comprehensive evaluation calculation, and the comprehensive evaluation vector B is obtained and the single-factor evaluation vectors are marked as B_{X1}, B_{X2}, B_{X3}, B_{X4}:

$$B = W^{\circ}R = \left(B_{X1}, B_{X2}, B_{X3}, B_{X4}\right). \tag{3}$$

For the results of the evaluation to be comparable, the data need to be normalized to obtain a comprehensive evaluation matrix. The fuzzy evaluation matrix of rehabilitation needs is as follows:

$$R_{X1} = \begin{bmatrix} 0.20 & 0.25 & 0.30 & 0.20 & 0.05 \\ 0.20 & 0.30 & 0.25 & 0.20 & 0.05 \\ 0.25 & 0.35 & 0.20 & 0.20 & 0.00 \\ 0.40 & 0.35 & 0.15 & 0.10 & 0.00 \end{bmatrix}. \tag{4}$$

In the same way, the fuzzy evaluation matrix of emotional demand, ease of use demand, and support demand is calculated, and then the evaluation vector is calculated by formula 3. For example, the evaluation vector of "rehabilitation needs" can be obtained from the weight vector W_2= (0.5426, 0.2359, 0.0995, 0.1221) of rehabilitation needs:

$$B_{X1} = W_2 \circ R_{X1} = (0.2294, 0.2840, 0.2600, 0.1878, 0.0389). \tag{5}$$

We also get the emotional need R_{X2}, easy to use requirements R_{X3}, support requirements R_{X4} evaluation vector of:

$$\begin{aligned} B_{X2} &= W_3 \circ R_{X2} = (0.2953, 0.2884, 0.2392, 0.1772, 0.0000), \\ B_{X3} &= W_4 \circ R_{X3} = (0.2971, 0.2989, 0.2679, 0.1360, 0.0000), \\ B_{X4} &= W_5 \circ R_{X4} = (0.2609, 0.3368, 0.2186, 0.1837, 0.0000). \end{aligned} \tag{6}$$

Sublevel evaluation scores and trends are shown in Figures 6(a) and 6(b).

Then from $W_1 = (0.3908, 0.1460, 0.1584, 0.3048)$, the comprehensive evaluation vector of the design scheme can be obtained: $B = W_1^{\circ}R = (0.2593, 0.3031, 0.2456, 0.1768, 0.0152)$.

The comprehensive score of the design scheme:

$$U = B \cdot V = 73.07. \tag{7}$$

5.5. Evaluation Results and Analysis. The evaluation set V= (very excellent, excellent, average, poor, very poor) was set at the beginning, and the weighted average value of the design scheme was 73.07 points. Comparing the obtained score with the evaluation set, it was concluded that the design scheme was in the "average" grade. It can be seen from Table 3 that the highest weight distribution value of the target layer is rehabilitation needs, but only 51.3% of the evaluation results are classified as excellent or very excellent, and the rehabilitation needs score is only 71.06, the lowest score. According to the score, the scheme has certain scientific rationality and can meet the needs of users of intelligent escort robots for the elderly with dementia. However, the program still needs to be improved in terms of the intelligent rehabilitation training function. According to the contribution value of each factor layer of rehabilitation demand, the improvement of the design plan should focus on memory training, executive ability training, and observation ability training.

6. Discussion

The main purpose of this research was to use a rigorous mathematical model to propose a new design idea for product design for the elderly with dementia. Judging from the research results, both accuracy and rationality meet the requirements of product design for the elderly with dementia, but this does not mean that the results of this research are completely rigorous. In the design plan of the intelligent escort robot for the elderly with dementia, it can be found that the key design directions are pointed out for the design plan through the analytic hierarchy process and the comprehensive fuzzy evaluation method. For example, memory training and executive training in rehabilitation needs, daily life services in support needs, and safe care. In addition, in the evaluation of the design scheme, the comprehensive score of the design scheme is 73.07, which also confirms that the scheme has certain practicability. Therefore, the design path of the dementia elderly care products based on the combination of F-AHP proposed in this article has a certain scientificity.

Through the analysis of the design demand hierarchy model, it can be found that rehabilitation demand has the highest weight in the design demand, accounting for 39.08%. In the previous review of the research results of relevant scholars in the medical field, it is also pointed out that rehabilitation physiotherapy is an important means for the treatment of patients with dementia, but the sublevel of rehabilitation needs

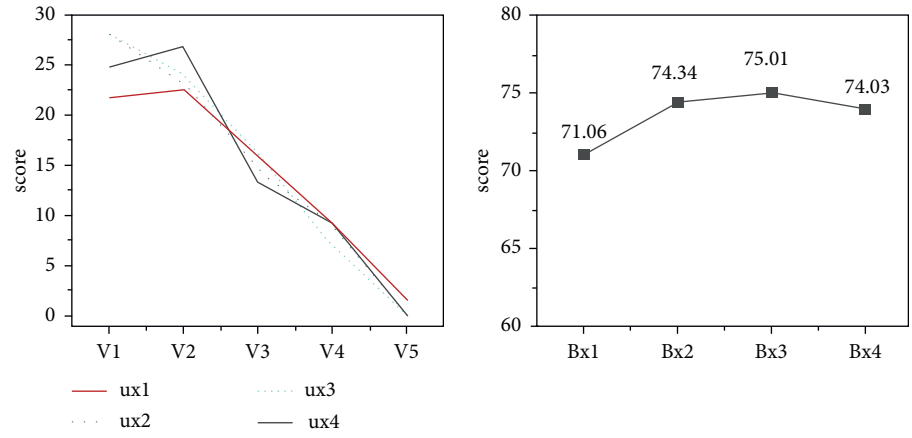

Figure 6: Score trend at all levels. (a) Evaluate element scores. (b) Hierarchy demand score.

Table 4: Criteria level rehabilitation needs judgment matrix and weight.

C_1	C_{11}	C_{12}	C_{13}	C_{14}	W
C_{11}	1	3	4	5	0.5426
C_{12}	1/3	1	2	3	0.2359
C_{13}	1/4	1/2	1	1/2	0.0995
C_{14}	1/5	1/3	2	1	0.1221

Table 5: Criteria level emotional needs judgment matrix and weight.

C_2	C_{21}	C_{22}	C_{23}	C_{24}	W
C_{21}	1	4	2	3	0.4491
C_{22}	1/4	1	1/4	1/3	0.0775
C_{23}	1/2	4	1	3	0.3181
C_{24}	1/3	3	1/3	1	0.1553

Table 6: Criteria level easy to use demand judgment matrix and weight.

C_3	C_{31}	C_{32}	C_{33}	C_{34}	W
C_{31}	1	1/2	3	1/4	0.1681
C_{32}	2	1	3	1/2	0.2683
C_{33}	1/3	1/3	1	1/3	0.0947
C_{34}	4	2	3	1	0.4688

is not specified. The design and design of escort for the elderly with dementia only provides a general direction and does not point out the specific design functional requirements. In this article, the weight proportion of each sublevel is calculated by the analytic hierarchy process. For example, in rehabilitation needs, the weight of memory training accounted for 54.26%, the weight executive training accounted for 23.59%, the weight observation training accounted for 12.21%, and the weight of calculation training accounted for 9.5%. Therefore, according to this result, we can know the focus of the functional design of rehabilitation needs. Compared with research in the field of

Table 7: Criteria layer support requirement judgment matrix and weight.

C_4	C_{41}	C_{42}	C_{43}	C_{44}	W
C_{41}	1	3	2	2	0.4015
C_{42}	1/3	1	1/3	1/3	0.0939
C_{43}	1/2	3	1	3	0.3212
C_{44}	1/2	3	1/3	1	0.1834

Table 8: Consistency index of average random number.

n	1	2	3	4	5	6	7	8	9	10	11	12
RI	0	0	0.52	0.89	1.12	1.26	1.26	1.41	1.46	1.49	1.52	1.54

Table 9: Consistency test results.

	O	C_1	C_2	C_3	C_4
λmax	4.1179	4.1627	4.1440	4.1855	4.2153
CI	0.0393	0.0542	0.0480	0.0618	0.0718
RI	0.89	0.89	0.89	0.89	0.89
CR	0.0442	0.0609	0.0539	0.0694	0.0807

design, most designers design for normal user groups directly through qualitative research methods. However, the target group of this study belongs to a special group, so it is necessary to use rigorous mathematical model analysis for auxiliary design. The research results show that the rehabilitation needs and support needs of the elderly with dementia should be met first, while ease of use and mental needs are auxiliary design needs. If the common design research method is also adopted for the design of accompanying products for the elderly with dementia, it cannot meet the needs and pain points of the elderly with dementia. Therefore, the design method proposed in this study is more suitable for the design of accompanying products for the elderly with dementia based on special user groups. However, through the evaluation of the intelligent companion nursing robot scheme for the elderly with dementia, it can be seen that the design requirements are only

Table 10: Weight ranking of nursing product design demand index set for the mentally retarded elderly.

Guideline layer (C)	Indicator layer	Weight	Sort
Rehabilitation need (C1) (0.3908)	Memory training (C11)	0.2120	1
	Perform competency training (C12)	0.0922	4
	Computing power training (C13)	0.0389	11
	Observation skills training (C14)	0.0477	8
Emotional needs (C2) (0.1460)	Accompany interactions (C21)	0.0656	6
	Mood diary (C22)	0.0113	16
	Age-appropriate entertainment (C23)	0.0456	9
	Wikipedia Q&A (C24)	0.0227	14
Ease of use demand (C3) (0.1584)	Easy to understand and operate (C31)	0.0266	13
	Fault tolerance (C32)	0.0425	10
	Easy to pick and place (C33)	0.0150	15
	Easy to interact(C34)	0.0743	5
Support requirements (C4) (0.3048)	Reminders for everyday life (C41)	0.1224	2
	Diet nutrition plan (C42)	0.0286	12
	Security care (C43)	0.0979	3
	Remote video (C44)	0.0559	7

guided by the priority of the design requirements obtained by the AHP, and the final scheme evaluation score is not very high. It shows that this design idea also has certain shortcomings. After the priority of design, requirements are obtained through the analytic hierarchy process, it needs to be combined with certain actual conditions when applied to the actual design scheme. For example, it can be seen from Figure 6(b) that in the scheme scoring of the intelligent escort robot for the elderly with dementia, the scores of spiritual needs and ease of use needs are higher. It shows that the behavioral habits and psychological emotions of the elderly with dementia should also be considered in the design. In the future further research related to the design of accompanying products for the elderly with dementia, when optimizing the design in the future, it is necessary to focus on the sublevel requirements with a high proportion of weight, such as memory training, daily life services, safety care, and executive training. However, it does not completely abandon the traditional design method, but this research method can be used when positioning the functional requirements, and the product entering the substantive design stage also needs to be combined with the basic design method. Based on meeting the functional requirements, it is also necessary to improve the service experience of users and design more excellent accompanying products for the elderly with dementia.

7. Conclusion

This research was aimed at the special user group of the elderly with dementia. It was necessary to propose a new product design method for this special group based on the traditional design method. This article adopted the analytic hierarchy process and fuzzy evaluation method to provide program design guidance and optimization direction for the design of intelligent escort products for the elderly with dementia. Through the research results, it is known that this design method has a certain guiding significance for the design of accompanying products for the elderly with dementia. And compared with the traditional design ideas, due to the particularity of user groups, the design method proposed in this study is obtained through the aid of quantitative analysis using mathematical models, rather than completely adopting qualitative analysis like the product design of ordinary user groups. This research calculated the priority of design requirements through the calculation of weight ratio, and then the priority of each functional requirement could be seen at a glance in the case design. In the fuzzy evaluation results of the intelligent escort robot for the elderly with dementia, the rehabilitation needs and support needs are the key points that need to be optimized in future design through comparison. Spiritual needs and ease of use needs have high evaluation scores, and it can also be known that the practical application of these two aspects needs to be considered more in the future design of the scheme. In general, the research in this article still has certain limitations. In further research, the design evaluation model will be continuously optimized to improve the scientificity of the design method of accompanying products for the elderly with dementia.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest with this article.

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