Hindawi
Journal of Sensors
Volume 2022, Article ID 5306491, 10 pages
https://doi.org/10.1155/2022/5306491

Research Article

Research on Furniture Design Integrating Ming-Style Furniture Modeling Elements and Image Sensor Data: Taking Suitable Old Furniture as an Example

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Received 27 January 2022; Revised 14 March 2022; Accepted 15 March 2022; Published 6 April 2022

Academic Editor: Zhongchang Wang

Ming-style furniture, adhering to the excellent traditional Chinese history and culture, is the pinnacle of traditional Chinese-style furniture, which vividly embodies the cultural essence of Chinese-style furniture. However, with the current popularity of smart home products, there are many obstacles for elderly users to use smart home products. Voice interaction is one of the main interaction methods of smart home products. The design strategy of voice user interface for aging smart home products is studied to improve the experience of elderly users in operating smart home products. Based on image sensing technology, combining Ming-style furniture modeling elements, and based on context theory research, this paper proposes four types of smart home contexts for elderly users, including user context, task context, time context, and environmental context, so as to propose a specific smart home product voice user interface design strategy. According to the user's situational characteristics, a multichannel interaction design of voice user interface is proposed, an emotional and personalized voice user interface is constructed, and a design strategy of context memory assisting the dialogue process is constructed. According to the task, time, and environmental situation of elderly users, it proposes design strategies such as active interactive voice user interface design and provides continuous behavioral service experience. *Conclusion*. The research results provide a method and strategy reference for the design and development of the voice user interface of smart home products and provide a more natural and comfortable experience of using smart home products for elderly users.

1. Introduction

Ming-style furniture is a manifestation of social stability and a developed agricultural handicraft industry in the Ming dynasty, and it is also a manifestation of rapid economic development. Carpenters and craftsmen gained more space, especially in the middle and late Ming dynasty, where the economy and commodities were abundant, foreign trade was opened, and the urban economy developed rapidly, especially in Jiangnan and Hainan, which made the various cultural customs and economics of the Ming dynasty exceed the previous generation. In the mid-Ming dynasty, the construction of residential buildings and private gardens entered a prosperous period, and a large number of buildings and gardens needed high-end furniture to furnish them. This created a large demand for Ming-style furniture. It also promoted the development of furniture manufacturing. A large amount of high-grade wood such as rosewood and red sandalwood were shipped back from Nanyang, which is rich in high-grade wood. The research of furniture craftsmanship and aesthetic exploration by a group of workers and cultural people in the Ming dynasty played a certain role in promoting the maturity of Ming furniture style. Ming-style furniture in China is the pinnacle and treasure in the history of Chinese furniture [1–5].

At present, most scholars and interior designers in China are very interested in understanding and researching the unique Ming furniture in China, especially scholars in universities. There are many articles and materials for learning in books, professional forums, academic journals, and

reports. Although there are many materials, the ones that are truly valuable are rare. Some of the current works did not fully display the cultural essence contained in Ming-style furniture, especially the understanding of the concept of Chinese elements, but this is also an opportunity for us to further improve [6, 7]. The requirements of the aging population for furniture functions must meet the requirements of both ergonomics and physiological functions.

On the other hand, the development of the Internet, Internet of Things, big data, and artificial intelligence technology has made smart home products widely used, providing users with intelligent and convenient services. With the increasingly serious problem of population aging, more and more elderly people come into contact with and use smart home products. Due to their physical, psychological, and behavioral particularities, there are more obstacles in the use of smart home products [8–11]. A good voice user interface design for smart home products plays an important role in improving the experience of elderly users. Due to the natural nature of the interaction method, voice user interfaces have good application prospects in aging smart home products, as shown in Figure 1.

With the support of increasingly mature voice interaction technology, voice interaction has become one of the interactive methods of smart home products. Some scholars have conducted research on the voice user interface of smart home products. Through emotional interaction experimental research, questionnaire analysis, and comprehensive data analysis, Liao and others have concluded that the degree of emotional interaction between users and smart home products determines the degree of personification of smart home assistants, and the degree of personification of smart home products voice assistants and user satisfaction is proportional. Zhou analyzed the characteristics of communication and dialogue between people and proposed a method of intelligent voice emotional interaction design. One is to perceive the user's emotional state, and the other is to automatically substitute the device into the corresponding situation and give the corresponding response. The above method is used to give the user provide matching services and content to meet the individual needs of users and enhance user experience [12–16]. Based on the physiological and psychological changes of the aging population, "furniture suitable for the elderly" should take safety and rationality as the primary principle; from an environmental point of view, the value of body changes, positioning, and activity routes should be considered, taking into account the use function and mental function and making the best possible. It may provide a safe, comfortable, and convenient life experience for the elderly.

Some scholars have also conducted research on the feedback time of the voice user interface. Li et al. obtained the speech rate information during the user's voice interaction process through experimental tests. They found that the control of the voice user interface feedback time can guide the user's interaction experience and emotional changes during the voice interaction process and proposed a speech rate detection module. It is added to the design of the voice user interface so that the user has a good sense of time in the interface experience. Chen and others conducted experiments on the feedback time of the voice wakeup link and voice dialogue link in the voice user interface of smart products. The study found that users have different needs for feedback time in different links of voice interaction, and different wakeup methods have their own. In a specific time frame, optimizing the feedback duration of the voice user interface is conducive to improving user experience and satisfaction [17–20].

Wu Yu made some design suggestions for the voice user interface in the smart home scene: one is to set the character model; the other is to incorporate a multichannel interaction mode, combining visual and voice channels to enhance the voice interaction experience; the third is to make mistakes for users prevent and correct, guide users to complete the correct input process. There are few researches on the voice user interface of smart home products for elderly users, and a small number of scholars have paid attention to this issue. Based on the status quo of aging, Jia Guozhong studied the possible problems of voice interaction for elderly users using smart home products. Through experiments, he found that the wakeup word design should be concise and choose a name that is easy for the elderly to remember. To wake up the system, in terms of voice task setting, elderly users prefer a warm and quiet female role; the content and logic of the dialogue should be concise and easy to understand. Wang Pankai takes the elderly companion robot as the research object, studies the voice interaction experience design method of the elderly companion robot, and builds the elderly voice interaction framework on the basis of analyzing the cognitive characteristics of the elderly and summing up the theoretical research on voice interaction. In the voice interaction design of the elderly companion robot, design strategies and methods such as self-explanatory voice interaction, custom wakeup words, automatic volume adjustment, and the addition of special language for the elderly are used [21–24].

In recent years, with the development of context-aware technology, adaptive user interfaces based on context-awareness are the main development trend in the future. Analyzing the smart home situation of elderly users and studying specific smart home product voice user interface design strategies are the basis for the design and development of smart home product adaptive voice user interfaces. However, there is a lack of research and exploration in this area in existing research. This is the research of this article, which provided an opportunity.

Driven by the country's favorable policy environment and industrial technological innovation in recent years, the Internet of Things has shown a strong momentum of development in various emerging areas of its industry.

After the 25th Five-Year Development Plan, the country has issued a number of policies that have a profound impact on the development of the Internet of Things industry. With the accelerated integration of mobile Internet and Internet of Things and the strong support of national policies, smart homes have become the layout and competition in the Internet of Things field [25–28].

Internet companies such as Google, Apple, Samsung, and Xiaomi have greatly promoted the layout of smart

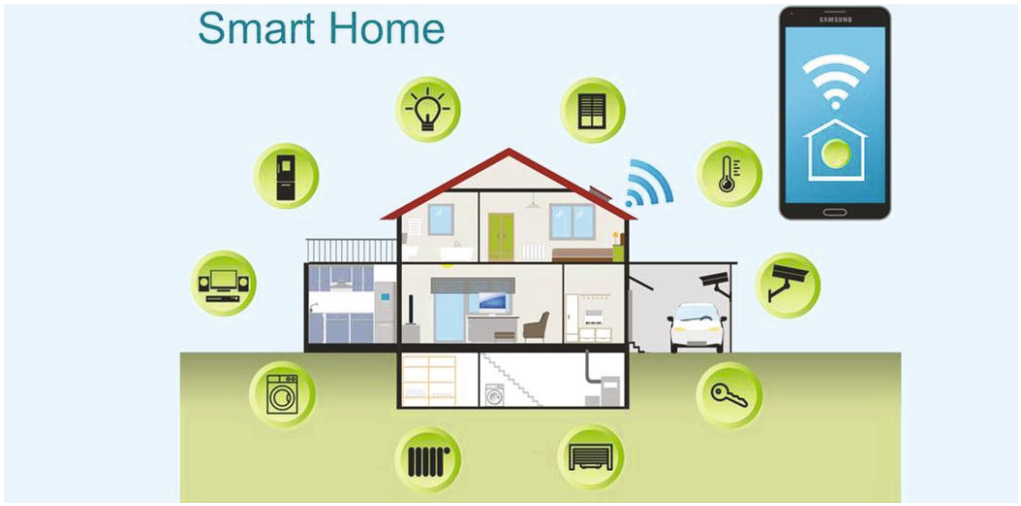

Figure 1: Smart home.

homes. At present, they have formed a series of innovative products such as smart home appliances and smart homes. These smart terminal products are combined with mobile applications to better serve users. Services are thereby attracting more and more users to deploy the smart ecosystem. China currently has 688 million Internet users, the largest number of Internet users in the world. Among them, the number of mobile phone users is unsurpassed by other countries. The 620 million mobile phone users give China a unique foundation in the "Internet+" industry. "Human and smart home" are fully connected to realize smart life.

(1) In terms of policy: driven by the favorable national policy environment and industrial technology innovation in recent years, the Internet of Things has shown a strong momentum of development in various emerging fields of its industry, and the development of Internet of Things technology has also been included in the national major science and technology projects. Following the formulation of the "Twelfth Five-Year" development plan for the Internet of Things, a number of national policies have had a profound impact on the development of the Internet of Things industry. Smart home, as the hottest field in the Internet of Things, has unlimited prospects. The national policy puts forward the two double + concepts of smart networking + smart "product + service", clearly pointing out and vigorously supporting the development direction of smart home

(2) Economic aspect: my country's smart homes are in the development stage. Although the market prospects are good, the current consumer awareness of smart homes is still lacking. Smart homes have a low level of education in the consumer market. Experience is also a factor that mainly affects consumers' purchase of smart home products. Second, the high prices of existing smart home products limit the level of consumer groups, and only higher-income groups will seek more convenience in life

(3) Social aspect: my country's smart home; the scale of the market has been expanding year by year, and the continuous rise of my country's national economy has also promoted the scale development of high-income groups, and the disposable income of residents across the country has increased year by year

(4) Technical aspects: the technological development of big data, Internet of Things, and cloud computing effectively promotes and integrates the overall development of smart homes. Although my country's technical fields are in the budding stage of the international level, the current government and various enterprises' judging from the support and experience of technology R&D investment, these technologies will continue to innovate in the future, and smart homes will also continue to develop. The development of China's smart home is in the growth stage as a whole, and the improvement of the overall technology will help drive consumers' interest in smart homes [29–32]

At this stage, the smart home market has been very hot, whether it is a variety of smart small hardware or the overall smart home wiring system, they have been made to look good. The vigorous development of the Internet industry has brought the world into the era of mobile Internet connectivity. With the continuous innovation of smart hardware, control methods other than mobile phones have gradually emerged. But at present, most of the smart home products are connected to mobile phones, and smart devices are controlled and monitored through mobile applications. Mobile phones have become the best control terminal for smart home products.

2. Analysis of User Needs of Suitable Old Furniture

Scholars have carried out research on the definition and types of situations. Bill Schilit and others put forward that

the situation contains three important aspects, including "where are you," "who are you with," and "resources near you". Dey defines context as any information that can be used to describe the status of an entity. An entity is considered to be a person, place, or object related to the interaction between the user and the application (including the user and the application itself). Chen believes that in the context of smart space, the concept of context provides a method for computer systems to automatically reason about the user's situation. Therefore, it allows the system to predict user needs and take actions on behalf of the user and proposes that in the smart space system, the user positioning, user identity, and user intent are commonly used contextual information in research. The color, material, and shape of furniture are the breakthrough points of emotional design. Combined with storage, limb assist function design, video communication, etc., we can coordinate to create an environment suitable for the life of the elderly and meet the needs of emotional interaction.

Dey enumerates the main context types describing the situation of a specific entity as location, identity, activity, and time. These context types not only answer the question of who, what, when, and where but also serve as an index to other contextual information sources. Ryan et al. divide the type of situation into place, environment, identity, and time. Dou Jinhua and Qin Jingyan proposed four types of situations: user, environment, task, and device. User context includes individual and social context. Environmental context refers to the physical environment. Task context includes user tasks and related events or behaviors. Device context includes device attributes and related events and other equipment attributes.

In family life, home furnishing products have a particularly close relationship with people, and home also integrates most of the contents of people's lives. Each family has different family members. There are free people living alone, a newly married couple, a sweet family of H, a happy family of three generations, and a rare family of four generations. Due to the characteristics of different families, the user differences faced by household products are very large, and there are also differences in abilities between each family member. This requires smart home products to take into account the versatility of the product at the beginning of the design. Usually, I have to conduct man-machine analysis before designing products, but I often ignore the needs of disadvantaged groups and only consider the standard of "healthy people." For the elderly, children, pregnant women, and disabled people in the family, household products are used much more frequently than barrier-free facilities in the public environment. In the process of designing products, safety and convenience should be considered. The user's ability and the size of the man-machine enhance the humanization of the product.

Based on previous research on the situational theory, the smart home situation of elderly users is divided into four types, namely, user situation, task situation, time situation, and environmental situation. The user situation includes the sensory, cognitive, and emotional characteristics of elderly users. The task context includes the purpose context and behavior context of the elderly users. The time context includes the time of daily events and the time of special events. The combination of structure and function of furniture should be simple and intuitive, the design should not be too obscure and complicated, and a certain guiding performance should be given to make it easy for the elderly to operate and save labor and convenience. The environmental context mainly includes physical environmental factors, as shown in Figure 2.

For the elderly and disadvantaged groups, smart home appliances are mainly used in the home, so the principle of universal design should be considered when designing. The user context of the elderly includes four aspects: sensory characteristics, cognitive characteristics, emotional characteristics, and personality characteristics of elderly users. With the increase of age, the sensory function of the elderly declines, and the sensory function of vision and hearing is the most common manifestation. The cognitive changes of the elderly refer to the obvious changes in the brain's ability to receive, extract, and judge information and cannot distinguish things smoothly and complete the task process. Cognitive changes are mainly manifested in attention, memory, perception, and thinking. In other aspects, cognitive ability will also change in strength and weakness with increasing age. Along with the physical decline of the elderly, their psychological status has also quietly changed, which affects the emotional state of the elderly in their daily lives. Personality is the essential psychological feature of an individual when facing himself or the outside world. The classic Big Five personality theory proposes five personality dimensions—extroversion, easygoing, conscientiousness, neuroticism, and openness. The personality of the elderly is affected by the synergistic effect of multiple factors such as increasing age, acquired life experience, and environment and also presents differentiated personality characteristics. The sensory characteristics, cognitive characteristics, emotional characteristics, and personality characteristics of the elderly are different. Universal design has seven principles: fair use, flexible use, simple and intuitive, perceptible information, fault tolerance, minimize physical effort, and provide enough space and size for users to be close to use. These principles provide a framework for the design practice of smart home products, but not only applicability must be considered in the design practice process but also other factors such as economy, culture, environment, and craftsmanship and other factors must be integrated into the product design. For example, the design of the handle avoids sharp shapes and is installed in a visually striking place, suitable for holding and exerting force, and has a damping device for easy opening and closing.

Purpose guides users to generate behavioral actions to complete the set tasks, and demand is the motivation for generating behavioral goals. Through literature research, observation, interviews, and other methods, analyze and extract the needs of the elderly in home life, including physiological needs, health needs, safety needs, social or emotional needs, information needs, entertainment needs, respect for needs, and needs for realization of self-worth. The predicted error is plotted in Figure 3.

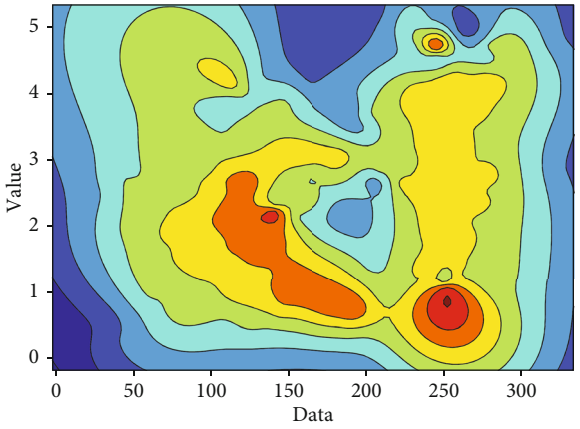

Figure 2: Data.

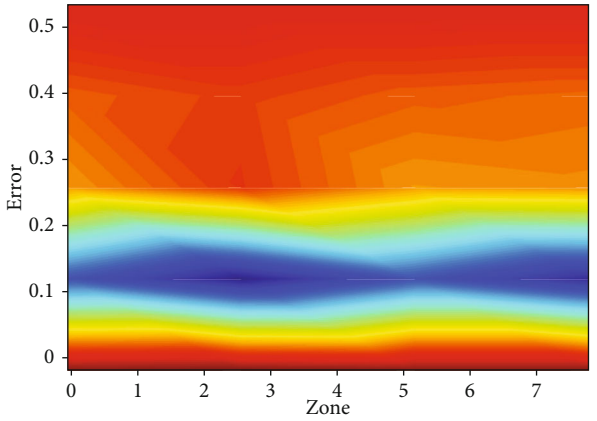

Figure 3: Error.

Leisure and social behaviors refer to behavioral activities that meet the spiritual and emotional needs of the elderly, including social interaction behaviors, cultural and entertainment behaviors, shopping behaviors, family interaction behaviors, and outing behaviors. The behavior types of elderly users are shown in Figure 4.

The home space is the main living environment for the elderly, and the physical environment is the main component of the home environment, including indoor temperature, humidity, light, and air quality. The outdoor physical environment includes temperature, humidity, ultraviolet index, and wind, which have a certain impact on the travel of the elderly. These factors are all environmental situations closely related to the elderly. Among indoor and outdoor environmental factors, quiet and noisy environments will have an impact on the experience of elderly users using the voice user interface, and the noise level is an important factor that needs to be considered in the design of an aging voice interactive interface. Universal design has seven principles: fair use, flexible use, simple and intuitive, perceptible information, fault tolerance, minimize physical effort, and provide enough space and size for users to be close to use.

Many mathematical models, such as activation functions, are required for the recognition technology of human action expressions. Generally speaking, the number output of the activation function is bounded and can be used as the input of the lower neuron. For example, the sigmoid function:

$$f(z) = \frac{1}{1 + e^{-z}}. \tag{1}$$

tanh function:

$$\tanh(x) = \frac{e^{x} - e^{-x}}{e^{x} + e^{-x}}, \tag{2}$$

where x means the variable.

Relu function:

$$\max(0, x). \tag{3}$$

In addition, the loss function is also used, which is also called the cost function. Random events or variables related to random events in the loss function represent possible damage or risk factors. The loss function is often used as the learning principle associated with optimization problems, that is, to minimize the loss function as an evaluation system. Usually, a machine uses many algorithms when learning. These algorithms correspond to fixed objective functions. When performing classification operations or regression operations, these objective functions can be improved. These objective functions are often loss functions. Time context includes daily event time and special event time. Most elderly people have regular daily life events, and the daily fixed event time is similar. Emotional interaction is an important component to draw closer to the elderly and smart homes. "Furniture for the elderly" can try to take advantage of this opportunity to combine emotional interaction with artificial intelligence technology to consider different types of elderly in detail.

The loss function is usually a nonnegative value function, used to evaluate the error between the predicted value and the true value Y corresponding to the system.

$$\hat{Y} = f(X). \tag{4}$$

The loss function can generally be expressed as

$$L(Y, f(x)). \tag{5}$$

There is usually a positive correlation between the value of the loss function and the performance of the model.

Suppose the sample set is

$$(X, Y) = (x_i, y_i), \quad y_i, i \in [1, N]. \tag{6}$$

There are N samples in total, among which the true value of sample i is

$$y_i, i \in [1, N]. \tag{7}$$

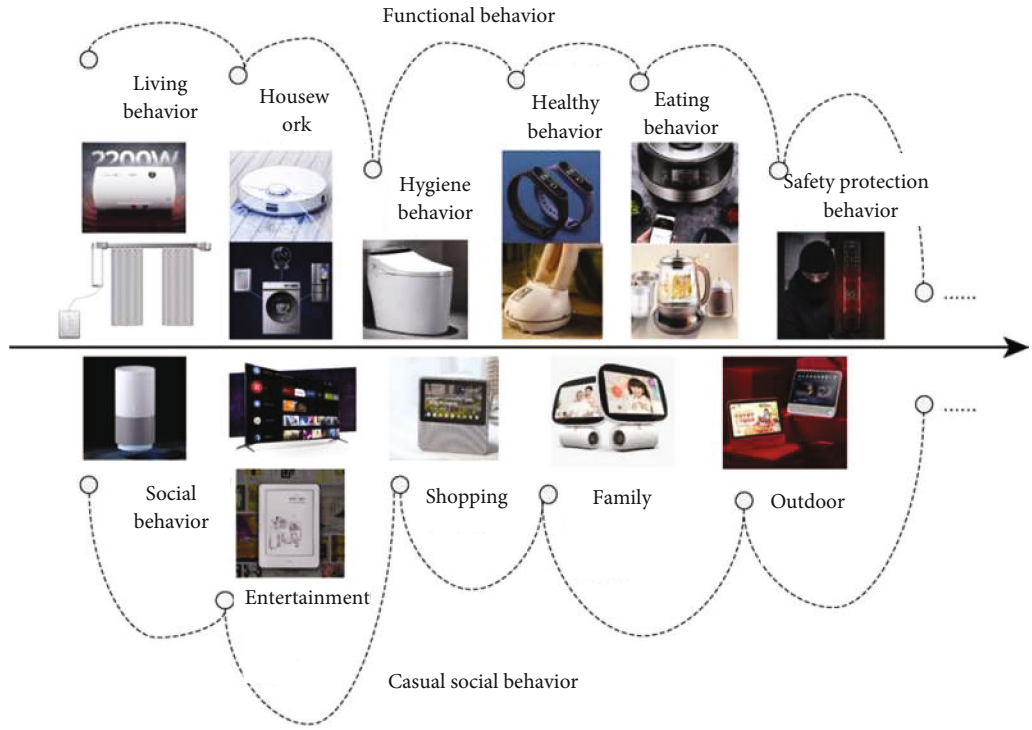

Figure 4: Social behavior.

The predicted value of sample i is

$$\widehat{y_i} = f(x_i), \quad i \in [1, N]. \tag{8}$$

f represents its classification or regression function. Then, the total loss function is

$$L = \sum_{i=1}^{N} l(y_i, \widehat{y_i}). \tag{9}$$

The commonly used loss functions in regression problems are average absolute error-$L1$ loss function.

The average absolute error (MAE) represents the sum of the absolute value of the difference between the estimated value and the target value. It is also a commonly used regression loss function, which reflects the average degree of error of the estimated value, and there is no need to explore the positive and negative of the error. The minimum average absolute error value is 0 and the maximum is ∞. The formula is shown in

$$L_{\mathrm{MAE}} = \frac{\sum_{i=1}^{N} |y_i - f(x_i)|}{n}. \tag{10}$$

Mean square error-$L2$ loss function: the mean square error (MSE) is the constant value of the error in the regression loss function, which is mainly used to represent the difference between the predicted value and the target value in the regression function value. In the process of use, it is generally squared. The function of this constant is expressed as follows:

$$L_{\mathrm{MSE}} = \frac{\sum_{i=1}^{n} |y_i - f(x_i)|^2}{n}. \tag{11}$$

The difference from the $L1$ loss function is that there is an additional step of square calculation.

The classification problem is more specific than the regression problem. The target quantity only exists in a limited set and is discrete. Classification problems are often one more step than regression problems and are used to judge categories. The loss function of the regression problem is the performance measurement function, and the loss function of the classification problem cannot be directly used for performance measurement. The final evaluation criterion is not the distance from the target, but the accuracy of the category judgment. In order to maximize the accuracy of category judgment, I need to define different loss functions for classification problems. These principles provide a framework for the design practice of smart home products, but not only applicability must be considered in the design practice process but also other factors such as economy, culture, environment, and craftsmanship and other factors must be integrated into the product design. Through reasonable function classification, augmented reality technology assistance, and improved system security, the necessary auxiliary functions are selected, and the configuration is optimized according to the specific characteristics of the

elderly, so as to improve the function integration of the smart home system for "suitable furniture for the elderly".

0-1 loss function: here, I take the problem of two classification as an example to explain the error rate = 1-the correct rate. At this time, the 0-1 loss function is defined as follows:

$$L = \frac{\sum_{i=1}^{n} I(f(x_i) \neq y_i)}{n}. \tag{12}$$

Cross entropy loss function (logistic regression): logistic regression is mainly used to solve two classification problems and can be further divided into loss function and activation function. The former is also called cross entropy function and the latter is called sigmoid function. The final target subformula is as follows:

$$L(\theta) = y \log (h_\theta(x)) + (1 - y) \log (1 - h_\theta(x)). \tag{13}$$

In this article, categorical_crossentropy is the main categorical cross entropy function. Compared with other functions of the same class, this function is more suitable for multiclass scenarios, and softmax is also used as the activation function of the output layer in the research process. For example, the time of getting up and going to sleep is relatively fixed every day, and the meal time in the morning, midnight, and evening is relatively fixed, and weekly exercise leisure time is also regular. The time of daily events has individual differences, and the regular schedule of the elderly in each family is different. In daily life, the elderly also has special arrangements for activities, such as shopping in shopping malls and other special events. These are some activities arranged by the elderly according to the special needs of their lives, which are uncertain and irregular. The full range of functional services in the context of networking provides a guarantee for the seamless connection between furniture design products and the behavioral characteristics of the elderly.

3. User Interface Design of Shilao Furniture

With the increase of age, the hearing and memory functions of elderly users decline, and single-channel voice interaction is likely to increase the cognitive load of elderly users. The voice user interface of aging smart home products uses voice as the main information interaction method and assists in visualizing visual information to enhance the voice user interface interaction experience and promote the multichannel perception of the voice interaction system by elderly users. Specifically, visual design is incorporated into the interactive process of voice wakeup, command input, information transmission, confirmation feedback, and other links. For example, in the voice wakeup link, the voice user interface responds with voice and is accompanied by a short light for visual response and combined with text, images, and other graphical user interface elements; in the instruction input link, supplemented by the graphical user interface to display the text information "in process," visually reminding elderly users that the voice input link is in progress; in the information in the communication link, the voice is the main way to interact with the elderly users, supplemented by text messages and light flashing effects to remind the elderly users that the information has been communicated; if there is an interruption in the voice interaction process, the voice prompts the elderly users whether they need to continue the conversation. In the feedback link, in the multiround dialogue mode, the voice is the mainstay and the graphical user interface assists in confirming the information. In the single-round dialogue mode, the dialogue is ended with a specific sound effect after the voice feedback. The value with different zone is shown in Figure 5.

In the process of voice user interface dialogue, understanding the pronouns used by elderly users is an important part of the continuous voice communication process. The cognitive characteristics of elderly users lead to pronoun ambiguity, unclear pronunciation, and dialogue content in the process of voice dialogue. For phenomena such as memory ambiguity, the voice dialogue must continue to track the context to achieve multiple rounds of dialogue and continuous interaction and promote the matching of high and low contexts in the voice interaction process. The context memory function of the voice interaction system needs to record the content information of multiple rounds of dialogue. In the process of continuous dialogue with elderly users, the voice user interface can prompt the elderly users to forget the information content according to the context information of the voice dialogue and continue the dialogue. Complete the voice service process.

The emotional needs of elderly users are an important factor considered in the design of the voice user interface of smart home products. The emotional voice interaction design analyzes the tone, volume, speaking speed, and other information in the voice stream of elderly users to perceive the emotional state of elderly users in the current situation. And adjust the tone, volume, speaking rate, and other states of the voice feedback in real time, and conduct appropriate emotional interactions with elderly users. For example, when the voice interaction system recognizes that an elderly user has sadness, depression, and other emotions, the system uses a gentle voice to talk to the elderly user and actively prompts the elderly user to use a certain system function through voice commands, such as video or voice with their children talking and listening to music or opera, as shown in Figure 6.

At the same time, in order to bring a more comfortable voice service experience to the elderly users, do not blame the elderly users when there are communication barriers at any stage of the voice interaction, so as not to bring frustration and failure to the elderly users and affect their response. The voice user interface should enhance error prompts based on contextual information, actively adopt a friendly dialogue mode, and understand and guide elderly users to smoothly conduct voice dialogues so that elderly users can maintain a positive and optimistic emotional state during the interaction process and improve the satisfaction of elderly users.

Design voice user interface assistants suitable for aging smart home products. Through the design of age, gender, appearance, speech speed and tone, dialogue content, etc.,

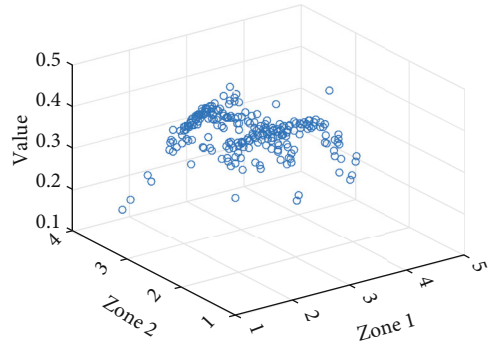

Figure 5: Value with different zone.

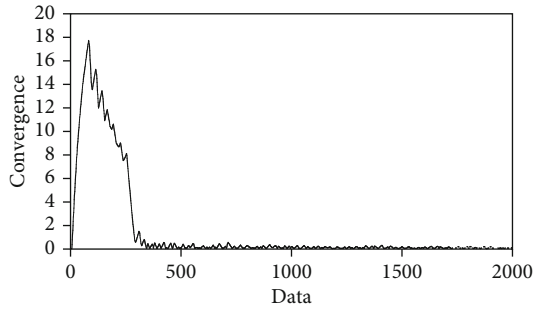

Figure 6: Convergence.

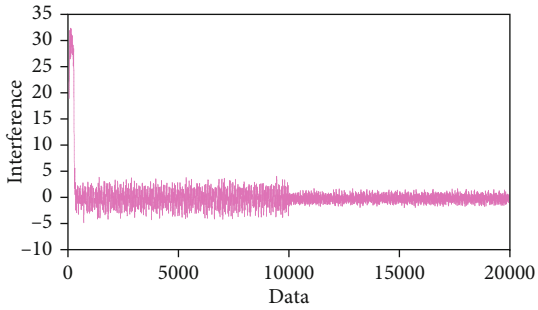

Figure 7: Interference.

voice assistants are given personality characteristics. The personalization design of voice assistants can easily make elderly users feel dependent. Sense of trust is to establish the trust relationship between elderly users in smart home products. By analyzing the personality characteristics of elderly users, smart home products can provide voice assistants that match the personality characteristics of elderly users. Take the elderly users with extroverted personality characteristics as an example. They are enthusiastic, active, self-confident, and talkative and like to interact with others. Aiming at elderly users with extroverted personality, the voice assistant is designed to be younger, confident and lively voice image, and dialogue tone. Too high, the conversation speed is fast, the frequency of active dialogue is high, and the colloquial language is added to the content of the dialogue to be closer to the personality characteristics of the elderly users. Take the Microsoft Personalized Dialogue System as an example. Microsoft Xiaoice is a personalized dialogue system entity, defining her personality to cover basic attributes and interest attributes, including the ability to interact with dialogue, sound, and vision, and the content of the dialogue reflects the set personality.

After many times of use, the voice interaction system records and analyzes the fluency of the communication process and common problems when the elderly users use smart home products to conduct conversations and actively provides voice assistance to guide the elderly users to learn and use the voice user interface of smart home products. Actively remind the elderly users of the operation methods and the functions supported by the equipment, and use video tutorials to assist the elderly users in memory and improve the self-efficacy of the elderly users in using smart home products. The interference of the proposed method based on MATLAB is shown in Figure 7.

The behaviors of elderly users are mainly divided into functional behaviors and casual social behaviors. From the perspective of task context, the voice user interface of smart home products should provide voice services that conform to the behavior context according to the behavior patterns of elderly users. Aiming at the functional behavior of elderly users, short command and question-and-answer dialogue are adopted to ensure the accuracy of speech recognition and improve the efficiency of task completion. For the casual social behavior of elderly users, it is necessary to ensure the comfort of natural voice communication and enhance the emotional experience of elderly users. The voice user interface of smart home products participates in the entire process from the generation of behavior to the end of the task, and the dialogue mode is automatically switched according to the type of behavior of the elderly users to ensure the continuity of the completion of the tasks in the smart home environment of the elderly users.

The time context of elderly users is divided into daily event time context and special event time context. Aiming at the time situation of daily events, the design of the adaptive voice user interface is designed according to the time and events on the timeline, and the characteristics of voice intonation, speaking rate, timbre, and volume are adjusted to adapt to changes in the status of elderly users. For example, in the morning, the elderly users are given a relaxed and pleasant atmosphere with a lively voice, and music services are recommended; while reading a book and the newspaper, a peaceful atmosphere is created with an elegant and soft voice, and question and answer services are recommended. The voice of the old users gives the elderly users a quiet and relaxing atmosphere and recommends storytelling services. For special event time scenarios, since the individual voice needs of elderly users are dynamically changing, the design of the voice interactive interface dialogue mechanism needs to take the initiative to respond to the voice needs of elderly users randomly. For example, elderly users tend to forget the time of special events. The voice user interface of smart home products provides the elderly users with the appointment function. By waking up the voice assistant, the voice assistant will be notified of the event and reminder time of the appointment. When the appointment time comes, the voice assistant will switch to lively. The voice

Figure 8: Smart home products for elderly users.

mode actively prompts elderly users to avoid the inferiority complex of elderly users with weakened memory. Figure 8 shows the voice user interface design strategy of smart home products in the time context of elderly users.

It provides environmental analysis reports and provides specific home and out-of-home recommendations to elderly users through a voice user interface. The feedback mode of the voice user interface of smart home products should be adaptively adjusted according to the environmental situation and the location and status of elderly users. When the elderly user is in a noisy environment, the voice user interface automatically improves the voice feedback of the voice interaction. When the elderly user is in a quiet environment, the voice user interface reduces the voice feedback of the voice interaction and performs voice interaction in a gentle way. The distance between elderly users and smart home products is dynamically changing, adjust the sound feedback according to the distance, so as to avoid the phenomenon that the distance is far away or the sound is too loud, which will cause discomfort to the elderly users. At the same time, the design of the voice user interface also needs to consider the static state or motion state of the elderly users themselves and adaptively adjust the volume and pitch.

4. Conclusions

The research of this paper includes the design of active interactive voice user interface and the construction of continuous behavioral service experience; for the time context, it proposes a design strategy for the daily event time context and the special event time context; for the environmental context, it proposes matching appropriate content services, adaptive adjustment design strategies for voice interactive feedback. The research results can provide designers and developers with a reference for aging-appropriate voice user interface design methods and strategies and provide elderly users with a more comfortable interactive experience of smart home products.

Data Availability

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

Conflicts of Interest

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

This article is the research result of the Humanities and Social Science Research Project in Jiangxi Province, "Research on the Risk of Excessive Use of Materials in Modern Home Decoration and Its Prevention and Control" (Project Number: YS20224).

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