



Explore the Demands of the Elderly by Integrating QFD and Scenario-Based Design

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Abstract. Cooking is an important behavior in daily life, but it is very easy to be dangerous in the kitchen. With the increase of age, the deterioration of physical functions causes many difficulties in cooking. The purpose of this study was to understand the difficulties of older people in the kitchen. In response to limited resources, identify the most urgent problems that need improvement, reduce the risks in the lives of the elderly, and achieve independent living and healthy aging. This study uses Quality function deployment combined with the participants' and experts' opinions to find the demand and physiological functions that need to be assisted and improved most, and provides a reference for future research, assistive devices and smart home development. Use Scenario-Based Design to discover more ideas for participants and gain a deeper understanding of the problems encountered by the elderly. In the end, the problem that needs to be improved is "Forgot cooking something and do something else". The physiological functions that need to be assisted most are hand stability, attention and memory. In the future, the development of assistive products for the elderly can be carried out in the direction of tactile feedback and vibration reminders. It can be used on hand devices in conjunction with other sensory functions.

Keywords: Quality function deployment · Scenario-Based Design · Sensory system · Elderly · Ageing · Ageing in place

1 Introduction

According to the United Nations report, the decline in fertility, coupled with longer lifespans, has led to global ageing population. The population over 65 years old has risen from 120 million in 1950 to 650 million in 2017 in the world. East Asia and Southeast Asia have the largest population of 261 million. It is estimated that the elderly population will increase to 1.5 billion by 2050 [1].

The demographic structure of society is rapidly changing because of the ageing population. The impact on society is comprehensive, including politics, economy, finance, culture, education and family [2]. Ageing is a common problem in the world, is an inevitable process in life. The time, speed, and results that occur in each person are different.

The literature points out that the ageing phenomenon of the elderly is roughly divided into five aspects, Physical function, Physiological function, Sensory systems, Psychological characteristics, Living structure [3]. The Sensory systems of the human body is important for receiving messages and dealing with environmental information. Hands are a significant tool for interacting with devices and the environment [4]. Degradation of sensory systems and Physical function have a great impact on life.

1.1 The Effect of Aging

Aging causes the deterioration of sight, hearing and touch. Due to the aging of the visual system, turbidity of the crystalline lens, yellowing of the crystalline lens, and reduction of pupil light adjustment, vision begins to decline at the age of 40–50 years old, resulting in reduced vision, reduced color, fear of glare, and adaptation time to light and dark becomes longer [5, 6]. Due to the degradation of the hearing system, the ability to hear and perceive information began to decline at the age of 40–45, the speech recognition ability decreased, and it was difficult to distinguish high-frequency chirping and low-vibration sounds, leading to hearing loss and even deafness. The ability to communicate with others is limited, causing social withdrawal [5]. The skin will also gradually become rough, the number of sensory cells will decrease, the feeling of cold and heat, light touch, pain will decrease, and the touch will be dull, which will cause problems such as difficult operation, trauma and burns, and agility decline [5, 7].

With the increase of age, the body function gradually deteriorates, the body size becomes smaller, Skeletal and joints weaken, and the ability to exercise is poor [3, 5]. After 65 years old, the function of the hand gradually declines [8]. The adverse effects of aging on hand function, including grip force, finger pinch force, and tactile sensation, have significantly decreased, leading to a decrease in the quality of life and independence of the elderly. Increasingly difficult to perform daily tasks [9, 10].

1.2 User Environment Demand

With the development of technology, there are many product-oriented design in the market, which is developed from the aspects of function and cost control. User-Oriented Design (UOD) emphasizes that users should be deeply understood, based on users' demand and expectations, using functions and technologies to turn requirements into products or services [11].

The literature refers to the “environmental docility hypothesis”, that stronger people are less susceptible to the environment, and those with lower ability are more dependent on external conditions and more susceptible to environmental impact. When the environment is in line with the ability, people can be more capable and independent [12]. Because the elderly needs an environmental suitable for their activity patterns and deteriorating sensory system [13]. Therefore, we should reduce the obstacles and difficulties for the elderly in the environment. Improve the satisfaction of life experience and the environment for users, rather than let users adapt to the under-designed environment [14]. For example, because the ability to receive light has dropped,

Lighting should be installed in the darker and where is easy to fall. For the elderly who is weak of hearing, the equipment used should be boosted [5]. In order to accurately change the living environment of the elderly and improve the satisfaction and pleasure of the elderly, understanding their environmental needs is the primary goal.

1.3 Quality Function Deployment (QFD)

Quality function deployment is a process of planning and communication. Use the House of Quality (HOQ) matrix to quantify the relationship between design decisions and product quality. Transform customer requests and technical elements into design criteria, identify priorities that affect design, and facilitate the integration of different positions within the company. identify priorities that affect design. Facilitate the integration of different positions within the company. HOQ manages the process of product development, improves product quality, reduces the number of design changes, and thus shortens time to market and lowers costs, making products easier to produce and closer to customer needs [15–17].

QFD has been widely used in manufacturing, in addition to developing products can also be used in development services [17]. Some literatures use QFD combined with FMEA method to explore service requirements [18]. There are also studies that provide improved and innovative priorities for medical processes by using QFD [19]. There are many physical functions caused by aging, but resources are limited. QFD can find out the important order of needs and improve the environment of the elderly in the most suitable and effective way [18].

1.4 Scenario-Based Design

Scenario-Based Design is a HCD (Human-Centered Design) perspective design method that uses situational description or script to expose user needs. By observing or collecting data such as photos, constructing one or more characters from the data to represent users can help better express behavior or feelings. Create a scenario that allows character activities to achieve goals, describe or visualize the process of character activities, and the feelings and decisions of each stage of the process. This method allows designers to better understand the characteristics of users and explore the relationship between the product itself and the context of use [20, 21].

Memory is a strange ability. The less information hidden in an image, the more memories you can recall. Black and white photos are more likely to inspire memories than color photos. Simple images may be more instructive than complex images. Because of the special representation of images, photo inspiration can evoke memories, feelings and messages. Compared to words, images evoke deeper elements of human consciousness [22, 23]. On the other hand, when the experimental environment is limited, it is impossible to conduct interviews in real places. Image Elicitation can help the participants to recall, and can evoke memories that are not remembered by verbal protocol.

1.5 Summary

Cooking is a very important behavior in life, and the kitchen is a very important room in the family [24]. Some studies point out that cooking improves survival in Taiwan's elderly [25]. In order to make the elderly successful ageing, "Active participation in life" and "healthy aging" are important [26]. However, the kitchen is usually the most vulnerable place for people in the home, because improper use of equipment or kitchen activities can cause injury and danger [27].

According to the above literature, we can understand that aging is an irresistible factor, and aging population is a global problem. There will be more and more elderly people in the future, but the current research on the needs of elderly people is insufficient. Although product-oriented can promote the development of new products, but user-oriented is closer to user needs. Aging in Place is promoted all over the world [12]. Safe and comfortable living at home is considered to be more beneficial to physical and mental state of the elderly [13]. However, when you are young, you can adapt to a environment easily, but may have problems in old age. This study uses QFD in combination with Scenario-Based Design to explore the problems and demands of the elderly and to improve the environment of the elderly. Image Elicitation was used for interviews to stimulate participants' perceptions of life and to explore problems. The field simulated by the visual card was set in the kitchen in the home environment. Although familiar but dangerous. QFD starts from user needs and turns requirements into design criteria. In response to limited resources, we can find the most urgent improvement needs and problems. It also provides a reference for the development of assistive devices for the elderly and the development of smart homes and kitchens.

2 Method

Aging causes the decline of human physiological functions. To improve the difficulties of the elderly, this study uses QFD and Scenario-Based Design to discuss the needs that elderly people will encounter in the kitchen to achieve the following goals:

1. Understand the difficulties of the elderly in the kitchen, provide more in-depth and comprehensive research reference
2. Identify the most urgent problems that need improvement and reduce the risks in the lives of older people
3. Promote the independence and quality of life of the elderly and make them healthy aging.
4. Provide references for future assistive devices and smart home development.

2.1 Participant

Some scholars distinguish elderly by age; "young old" is 65–74 years old, "mid old" is 75–84 years old; "old old" is over 85 years old. The aging can be divided into three stages according to the Activities of Daily Living (ADLs): The "primary aging" elderly people have some aging characteristics, such as white hair, spots on the skin, loss of vision, hearing loss, etc. Although there are some degradations, they are healthy and

comfortable; The “secondary aging” of the elderly is affected by diseases and bad habits, leading to a decline in physical function, mental and cognitive function, and requires help from others; “tertiary aging” because of the rapid decline of various functions, the elderly are sick in bed or unable to act on their own [28]. From the above literature, we know the differences in the aging stage of elderly people. Most elderly-related studies have set the age to be over 65. But for the Participant who is about to enter old age, participant conditions for this experiment were limited to 55 years old and above, and the “primary aging” elderly with cooking habits.

2.2 Experiment Setup

This experiment mainly uses QFD as the experimental method, as shown in Fig. 1. The following will be described separately according to the experimental process:

1. Demand element (DE)

Use QFD to find hand problems in the life of elderly people. Prepare kitchen simulation cards in advance, including common cabinets, counters, refrigerators, gas stoves, sinks, dining tables and chairs, and draw corresponding windows, walls and doors on site. Through Image Elicitation, participants were simulated to reproduce the kitchen scene and interviewed, as shown in Fig. 1. Finally, the final DEs are obtained through coding in Grounded Theory.

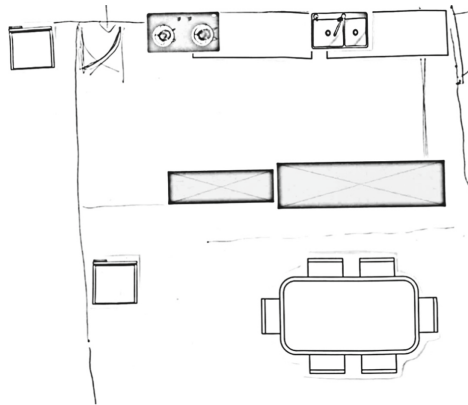


Fig. 1. Example of kitchen simulation card

2. Physiological function element (PFE)

Derive PFE using DE.

3. Demand function matrix

Explore the relationship between DE and PFE, add expert opinions, and grade the degree of correlation between each demand and function, 0–5 points, the higher the score, the stronger the relationship between the elements, and finally get the average of the degree of correlation, then converted into a pattern and filled into the demand

function matrix to complete the relationship matrix. Irrelevant is 0 points, do not fill in the matrix; very uncorrelated is 1 point, expressed as Δ ; moderate correlation is 3 points, expressed as \circ ; extreme correlation is 5 points, expressed as \odot complete the relation matrix.

4. Problem importance

Through the questionnaire, the importance of DE to the participants was obtained. DE is used as a questionnaire item, and each item uses a 5-point Likert scale for importance ranking, with 1 being the least important and 5 being the most important. Questionnaire items include age, gender, frequency of cooking, occupation, hand disease, operational difficulties, DE importance, frequency of encountering DE problems.

5. Weight to complete HOQ

The DE importance is converted to the PFE importance. The Experiment setup of this study is shown in Fig. 2.

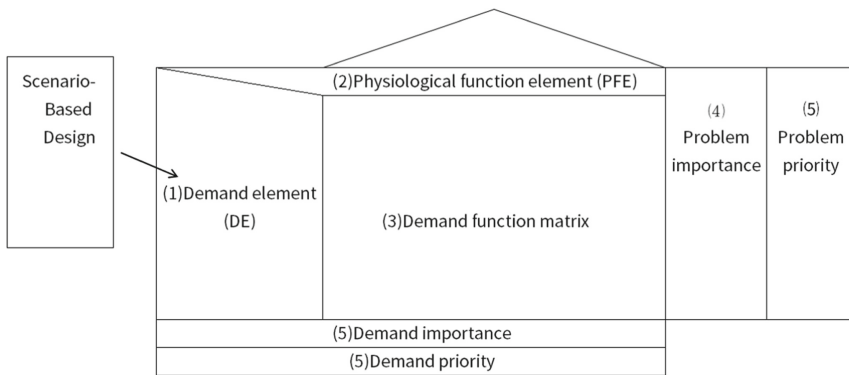


Fig. 2. Experiment setup

3 Result

3.1 Demand Element (DE)

In response to the problems encountered in the home environment, interviews were conducted with 6 participants participating in observation and Image Elicitation. Analyze and encode the collected data, using three coding methods of Grounded Theory: open coding, axial coding, selective coding. During the coding process, different nodes can be repeated [29, 30]. First, the transcript obtained from the interview is segmented line by line in open coding, and the sentences are subdivided and named to obtain 53 sentences. The similar concepts are roughly classified into 24 sub-categories, and the sentences in each sub-category are classified as: Unresolved problems and dilemmas, Resolved problems or alternatives, Descriptive statements. From the sub-category, 14 categories are integrated, and the common problems and unresolved problems of the participants can be seen. Finally, the four common kitchen

problems are summarized, which means that the problem elements of the elderly are derived. They are “Get scald when cleaning the gas stove and countertop and moving the pan”, “Cut the hand while using a knife”, “Feel burdened when using the pan”, “Forgot cooking something and do something else.” The DE of this research is on the left side of Fig. 4.

3.2 Physiological Function Element (PFE)

Based on previous literature, interviews, and observations, we summarized all the physiological functions related to the DE. In the end, we got six PFEs, which are “Temperature sensitivity”, “Attention”, “Memory”, “Vision”, “Tactile acuity”, “Hand stability”. PFE is shown at the top of Fig. 4.

3.3 Demand Function Matrix

The questionnaire was used to collect the opinions of 5 experts, including 4 medical background experts, with an average experience of 18 years, and 1 expert with relevant medical knowledge and design development experience, 4 years. Explore the relationship between DE and PFE, and finally get 5 unrelated, 9 low correlation, 5 moderate correlation, 5 highly correlated items. The Demand function matrix for this study is shown in Fig. 4.

3.4 Problem Importance

Data Analysis

A total of 39 questionnaires were returned, including 32 valid samples and 7 invalid responses. The response rate is 82.05%. Most of participant cook every day, and the samples are divided into three groups by age, 55–64, 65–74, above 65 years old. Women are the majority of all participants. Data of demographical as shown in Table 1. The average value of DE importance is shown on the right side of Fig. 4.

Table 1. Data of demographical

Items	No	Percentage
Age	55–64	11 34.4
	65–74	7 21.9
	75+	14 43.8
Cooking frequency (days/times)	1	21 65.6
	2	6 18.7
	3	3 9.4
	20	1 3.1
	26	1 3.1

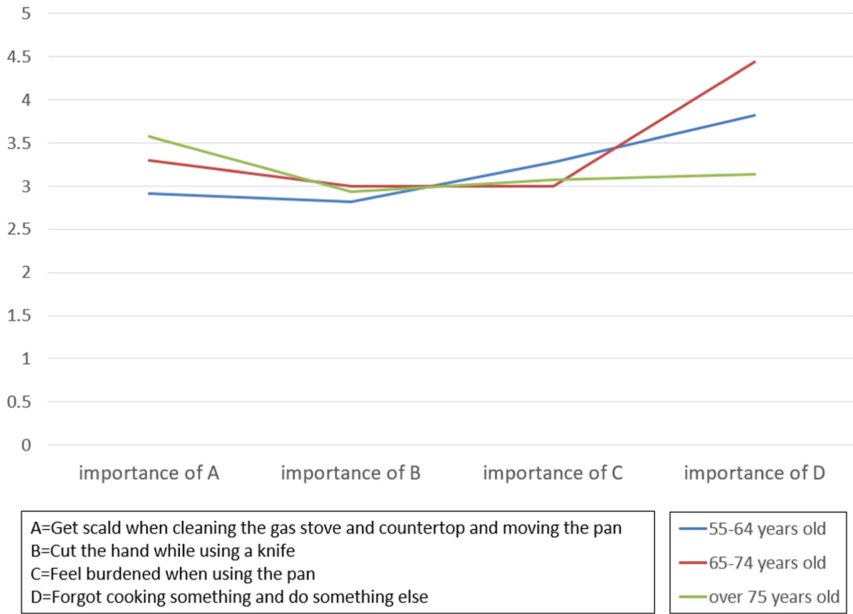


Fig. 3. Line chart of the average of the importance in each age group to the DEs

We performed Analysis of Variance (ANOVA) for the importance and age of each DE. The homogeneity is 0.238, 0.323, 0.271, 0.075, which are all greater than 0.05, indicating that the sample is homogeneous. The importance of the four questions is not significant between the three age groups, which means that the importance of the questions to the subjects does not differ significantly with age. A line chart of the average of the importance in each age group to the DEs is shown in Fig. 3.

The frequency of occurrence of DE is converted into a score, 4 points for sorting 1, 3 points for sorting 2, 2 points for sorting 3, and 1 point for sorting 4. Calculating the average number can be found in the order of high to low frequency: “Get scald when cleaning the gas stove and countertop and moving the pan”, “Feel burdened when using the pan”, “Forgot cooking something and do something else”, “Cut the hand while using a knife”. The average number of DE occurrence frequencies is shown in Table 2.

Table 2. The average numbers of DE occurrence frequencies

DE	Frequency of occurrence
Get scald when cleaning the gas stove and countertop and moving the pan	2.84
Cut the hand while using a knife	2.25
Feel burdened when using the pan	2.50
Forgot cooking something and do something else	2.41

3.5 Weight to Complete HOQ

After filling in the DE importance and relationship matrix, use the independent collocation method to multiply the DE importance by the correlation degree in the corresponding relationship matrix (1 point, 3 points, 5 points), and add up to get the total score of the PFE. Prioritize the PFEs to complete HOQ. The PFE of this study is shown in Fig. 4.

Physiological function element (PFE) Demand element (DE)	Temperature sensitivity	Attention	Memory	Tactile acuity	Vision	Hand stability	Problem importance	Problem priority
Get scald when cleaning the gas stove and countertop and moving the pan	○/ 9.84	○/ 9.84	△/ 3.28	○/9.84	◎/16.4	◎/16.4	3.28	2
Cut the hand while using a knife		○/ 8.73	0	△/2.91	△/2.91	◎/14.55	2.91	4
Feel burdened when using the pan	△/ 3.13	△/ 3.13	△/ 3.13	△/3.13	△/3.13	◎/15.65	3.13	3
Forgot cooking something and do something else	△/ 3.66	○/ 10.98	◎/ 18.3				3.66	1
Demand importance	16.63	32.68	24.71	15.88	22.44	46.6		
Demand priority	5	2	3	6	4	1		

Fig. 4. HOQ

We can know the priority level of DE from HOQ, list in sequence: “Forgot cooking something and do something else”, “Get scald when cleaning the gas stove and countertop and moving the pan”, “Feel burdened when using the pan”, “Cut the hand while using a knife”. After weighting with the relationship matrix, the priority levels of PFE are obtained, list in sequence: “Hand stability”, “Attention”, “Memory”, “Vision”, “Temperature sensitivity”, and “Tactile acuity”.

4 Discussion

In order to better grasp the difficulties and problems of the elderly in the kitchen, from the data obtained from interviews and Scenario-Based Design, we can roughly see the tendencies of the needs of the elderly. After coding, find out the context of the problem, and get DE and PFE. Discuss the deduction with experts, and get the relationship between DE and PFE. According to the questionnaire, it is found that among these kitchen problems, the most urgent problem is “Forgot cooking something and do something else”. The more relevant PFE is attention and memory. “Get scald when cleaning the gas stove and countertop and moving the pan” is a secondary issue. The more relevant PFE is hand stability and vision. The third most important issue is “Feel burdened when using the pan”. The most relevant PFE is hand stability, and the last question is “Cut the hand while using a knife”, and the more relevant PFE is hand stability and attention. Older people think that the most important problem is different from the most frequently encountered problem. The most important problem is “Forgot cooking something and do something

else” The most frequently and common problem is “Get scald when cleaning the gas stove and countertop and moving the pan”. From the interviews, we can know that the elderly people think that the higher-risk problems are more important. Their own injuries are secondary. Forgetting the gas stove may cause fire. Although the burns are most often encountered, the results are relatively minor.

After constructing HOQ and weighting, the elderly’s functions in hand stability, attention and memory need to be assisted and resolved. The following discusses hand stability, attention and memory.

In activities of daily living (ADLs), hand functions and skills are a big part of performing work and tasks. The work of the hand is extremely subtle and sensitive, and it also requires a lot of strength. It is the most important part of the upper limbs. Decreased hand function reduces the quality of life and independence of the elderly. Hand degradation includes grip and pinch, hand dexterity, posture maintenance, and speed [8, 9]. It may be due to decreased muscle coordination, finger agility, and hand sensation and degeneration of the central nervous system [9]. It is closely related to the degradation of skeleton, blood vessels and nervous system. It can be subdivided into joints, muscles, tendons, skeletons, nerves and receptors, blood supply, skin and nails, and distance changes controlled by nerves, etc. [8]. The hand function of the elderly decreases with age after age 65, and the age difference becomes more pronounced after age 75 [8, 10]. As women age, they degenerate more severely than men [9]. Consistent with the results in this study that women encountered “Feel burdened when using the pan” frequently. It varies with pathological conditions (osteoporosis, osteoarthritis, rheumatoid arthritis, and Parkinson’s disease) [8].

The cognitive process of older people changes with age, and certain types of memory decline. Cognitive control may be worsened by damage to the prefrontal brain area [31]. Distractions have an adverse effect on memory function. The increased attention load reduces the ability to participate in fine coding by the left prefrontal cortex [32]. The decline in memory and attention may cause many inconveniences and dangers in life. Our memories are networks of interconnected cortical neurons, formed by association, that contain our experiences in their connective structure. The composition of cognition and working memory comes from the activation and association of experience. Internal and external stimuli can reactivate memory [33].

5 Conclusion

Everyone gradually gets older, in the age when the average life expectancy is getting longer and the fertility rate is declining. The problem of the elderly has been highly valued, but the difficulties derived from the older society are still a big challenge. In the interview, we can learn that many elderly people will find ways to adapt to the problem, ignore the problem, or simply give up the task completely, resulting in injury, illness, or limited life. Such a vicious cycle ultimately leads to the elderly’s restricted lives, physical and mental health, and loss of independence. In the declining physiological functions and limited resources, how to accurately find the problem points, the most effective assistance and improvement of the elderly’s life is very important work.

Scenario-Based Design can explore more ideas of Participant and let everyone know more about the problems that elderly people will encounter in the kitchen. QFD can combine the opinions of Participant and experts to unify the needs of the problems to improve, and find out the most requires auxiliary physiological functions. The problems that need to be improved most are “Forgot cooking something and do something else”, and the most important physiological functions are hand stability, attention and memory.

5.1 Limitations of the Study

The field of this study was set in the kitchen, but the majority of the households responsible for cooking were women, resulting in more women participants than men. The results are more suitable for women than men, but the problem of men in the kitchen also needs attention. Compared to eating outside, cooking by yourself can better control your diet and health, so cooking is an important activity for both men and women. During the interview, it was found that most of the participants did not have a specific concept of tactile sensation, and were less active in improving the degradation of tactile sensation, or even failed to detect the tactile-related degradation, which may cause deviations in importance and affect the research results.

5.2 Support and Improvement

Inspired by interviews and literature, here are a few ways to provide assistance with hand stability, memory, and attention.

- Stimulation enhances muscle coordination and the nervous system. Peripheral nerve stimulation can affect functional measures of motor performance. Some scholars have used median nerve stimulation to increase the muscle strength of patients with chronic stroke. Two hours after stimulation, the pinch of the hand increased [34]. Another study pointed out that an imperceptible, random frequency vibration was simultaneously applied to the wrist during hand movements. This sensory stimulus has an effect on the sensorimotor cortex and can also be used for neurological rehabilitation [35].
- Aids memory and attention through information stimulation. Human sensory systems are channels for receiving information, and can be used to assist attention and memory through vision, hearing, and tactile channels. According to previous research by the team, four different materials of mobile phone screen protectors were used to evaluate the usability of elderly people over 50 years of age. The results showed that the touch protectors with matte texture are more beneficial to the elderly using mobile phones [36]. Another study by the team explored the application of vibration feedback, and the results showed that vibration feedback is a good supplement for the elderly [37]. Haptic feedback is a good way to receive messages. Tactile messages can be sensed without special attention, which can effectively improve the use and operation of elderly people.

In the future, the development of assistive products for the elderly can be carried out in the direction of tactile feedback and vibration reminders. Combined with feedback from other sensory system, it can be used on hand devices. Vibration can also stimulate

nerves, strengthen muscle strength, reduce problems encountered in kitchen operations, improve the independence and quality of life of elderly people, and achieve healthy aging. In the future, this research framework can be used for other demand. The field can be set at different locations, and different auxiliary devices are made for different situations and objects. It can also be used to explore the needs of people with disabilities, intelligent home, and solve daily environmental difficulties. Reduce the risk of facing danger, and improve the quality and satisfaction of life experience.

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