Identifying the requirements of elderly solitaries in China for interactive smart home design

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Abstract

Context: In recent decades, more than 200 million rural-to-urban migrants of working-age moved to and temporarily lived in cities in China. This migration contributes to the so-called empty nest phenomenon (i.e., changes in psychological well-being of parents when children leave their home). As time goes on, many of the empty-nest elderly will be in the statement of spouse-bereft and living alone. Compared with elderly people who live with their spouses, elderly solitaries have relatively worse psychological status. Most of existing smart home designs for the elderly are focusing on performing different functions packaged into friendly user interfaces, but emotional perspectives are scantily taken into account or are ignored.

Aim: This thesis aims to explore the real demands of elder people living alone in China in order to inform the design of smart home systems that satisfy both physical needs and psychological needs.

Method: The research procedure obeys the human-centred lifecycle model steps starting from identifying needs for design, to understanding the context of use, to completing requirements specification work. A literature review on existing smart home modes for the elderly was conducted to collect requirements defined by previous researches. In addition, 22 field interviews in three groups (elderly solitaries over 60, elderly between 50-60, and children generation of elderly solitaries) were conducted in Xiamen city of China for gathering and analyzing the real demands. Requirements are finalized by integrating prior studies and the interview data analysis.

Results: I found that for older people (over 60 years old), their needs and expectations mainly form four aspects: they wish they could live orderly (daily life), could keep aware of their body condition (health care), could be rescued in time once emergency occurs (emergency response), and could have initiative contacts frequently with their children (emotional solace). Compared with them, the elderly between 50-60 have demands for higher quality lives. They have the ability to operate intelligent products, and squint towards the conjunction of online and offline lifestyles to enrich their life. As for the children generation, they wish their parents could have the resources to develop their own interests and have friends around as companions.

Contribution and future work: This thesis makes contribution to the design of smart home systems for the elderly by providing comprehensive requirements. Possible future research extension can be the realization of smart home system based on the requirements gathering in thesis.

Keywords
Solitary elderly people, requirements gathering, human-centred design, smart home.

Supervisor
Dr. Dorina Rajanen
Foreword

Time rush, I have been in the University of Oulu for almost two years. During the two years of study, I have experienced the different teaching and learning styles compared with Chinese universities, and also have the opportunity to see the midnight sunshine with my own eyes. I appreciate the opportunity that given by GS3D programme.

I started to write this master thesis after last summer holiday. From the selection of topic to the final version, I went through all stages with the support from my supervisor Dr. Dorina Rajanen. She is a very humble and rigorous scholar. Her guidance not only contributed to the quality of this thesis, but also deepened my logical thinking. I appreciate her support very much! Besides, I appreciate the opinions that came up by my opponent Professor Kari Kuutti for improving my thesis.

At last, I would like to express my appreciation to the participants who were willing to accept my interviews, I hope them could live in a happy life, and I wish my research could help the elderly to live in a better life.

Dong Li

Oulu, May 10, 2016
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1. Introduction

Due to the decrease in fertility and mortality, the population is aging rapidly in China in recent decades (Cheng, Rosenberg, Wang, Yang, & Li, 2011). As the working-age children left home, their parents become empty-nest elderly. With time passing by, many of them will gradually be in the statement of spouse- bereft and living alone. Home endowment refers to the elderly preference to live at their own homes instead of being institutionalized; this is in accordance with Chinese national habits, which is the traditional culture of China, and satisfies the majority of the old people’s aspirations as well, even they know the process of aging is accompanied by decreasing physical and cognitive abilities. With the accelerated growth of the elderly population, the highlighted issues of empty nest elderly people, and the aging people, endowment crisis is coming to China. Elderly solitaries are not only in face of bodily functions aging, but also coming across following living inconvenience and psychological negative emotions. With the maturity of the Internet of things technology, an innovative trend for home endowment- smart home systems and services appear, which can meet solitary aging people’s demands of living independently and safely.

In this context, I aim to explore the potential and in-depth demand of old-age home endowment by a qualitative research, with the purpose of enabling the elderly to live independently, safely, and happily with the application of smart home systems.

The research method used in this thesis is qualitative research based on human-centred lifecycle model and assisted with field interviews to collect data for generating requirements.

1.1 Social background

The trend of population aging and single family has become increasingly evident. According to The State Statistics Bureau (2015), at the end of 2014, the population of elderly people over 65 years old has reached 137.55 million, 10.1 % of the total population of 1.367 billion in China, which has been beyond the international measurement (7%). According to the statistics (Peng, 2010), empty nest families account for 49.7%, in large and medium-sized cities, the percentage even reach 56.1%, and one third of the empty nest families are solitary aging people. In the report of China aging career development in 2013, Chinese Academy of Social Sciences (2013) points out that the number of Chinese empty nest elderly people is around 36 million, in which solitary old people is around 200 thousand. According to an estimate, in 2050, the amount of Chinese elderly people over 60 years old will be 483 million, and empty nest aging people account for more than 54% (Figure 1).
Figure 1. The growth of elderly people population and the percentages of empty nest elderly people and solitary elderly people according to Chinese Academy of Social Science (2013)

Solitary elderly people that are in a rapid growth are facing both physical and psychological problems (Xing, 2007). Physically, more than 70% of the Chinese elderly are suffering from chronic age-related diseases, 15% are even suffering from serious diseases that require lifelong treatment and nursing care, improper care will easily lead to many complications; in addition, there are more than 9 million elders in China afflicted with dementia, ranging from 3.2% to 9.9% among elders living in different areas of Mainland China (Fang et al., 2015). These numbers will undoubtedly escalate as the demographic feature progresses to a large elderly population. Psychologically, elderly people will have a long distance with the society, and lack of communication with outside world, it will likely cause mental health disorders, including dementia and depression and other negative feelings, some of them prefer to commit suicide resulting in tragedy. Economically, a part of solitary aging people have low income that is not enough to afford a life with good health protection, that would lead to a vicious circle.

1.2 Cultural background

In 2002, World Health Organization (WHO) came up with a concept named “active aging”. “Active aging is the process of optimizing opportunities for health, participation and security in order to enhance quality of life as people age” (WHO, 2002). Similar concepts such as successful aging (Rowe & Kahn, 1997), healthy aging (Bartlett & Peel, 2005), and positive aging (Bowling, 1993) have been put forward to enhance elderly people’s quality of life. In ideal active aging life, potential for physical, social, and mental well-being can be realized by life-course and participation in society, while providing elderly people with adequate protection, security and care when they need (WHO, 2002).

Different from the Western culture, in China, family has been the traditional source of support for economic assistance and care for elderly. Older people generally cannot accept agency or community endowment, they prefer to been nursed by extended families, especially their children. Home endowment is a manifestation of Chinese traditional culture – “filial piety”("孝(xiao) in Chinese"), and now is threatened by new social economical changes. In 2000, 100 working-age people need to be responsible for the endowment of only 15.6 elderly people in average, but in 2050, the average number will rise to 48.5 (Yan, 2007). Especially since the implementation of the one-child policy,
the emergence of “4-2-1” (four grandparents, two parents, and one child) family structure lead to a phenomenon that a couple is facing the burden of both supporting all 4 parents and raising one child. Burden arising from the endowment is not limited to economic aspects, but also spending more time to take care for the daily life of the elderly people (Xinhuanet, 2005). In recent decades, more than 200 million rural-to-urban migrants of working-age moved to and temporarily lived in cities with the intention to grasp better employment opportunities because of the speedy economic growth in China (Fang et al., 2015). This urban migration contributes to the empty nest phenomenon. Fang et al. (2015) point out that “the ‘empty nest’ is negatively associated with life satisfaction, and ‘empty nest’ elders manifest a higher incidence of depression and loneliness, and have an urgent need for geriatric care services, especially home care” (p.5).

1.3 Technical background

The concept of Chinese traditional elderly people endowment is having delicate but also tremendous changes with the development of technology. Penetrations of information technologies in all life-aspects have altered their original faces. Nowadays, not only people, but also a variety of devices and gadgets ranging from mobile phones to “smart houses” elements are united by the Internet. A concept named The Internet of Things (IoT) is developed based on the idea of a universal contact of things or objects, such as Radio Frequency IDentification (RFID) tags, sensors, mobile phones, etc., with digital identification and addressing schemes that enable them to cooperate with each other in order to achieve some common goals (Santos, Macedo, Costa, & Nicolau, 2014). The Internet of Things (IoT) is defined as a new paradigm, which is a combination of aspects and technologies (Borgia, 2014).

At the same time, in the environment of IoT, conventional ways of thinking are broken through IntelliSense Technology, identification technology, and pervasive computing (Hu, Wang, Zhou, & Zhao, 2015). The appearances of blood pressure monitors, smart wearable devices and other healthcare products play a key role in the enhancement of convenience for medical equipment to measure the health indicators, such as blood pressure, blood glucose, blood lipoid, etc. What is more, owing to the emergence of cloud computing, it enables easy access to a wide range of information from disparate sources such as electronic medical records, claims, medication and laboratory data. Smart home endowment is the upgrade and optimization of the traditional retirement home, combining the advantages of cloud computing technology and health care management, allowing children to keep them updated on the health condition of their parents.

1.4 Statement of the problem

There is a general preference of elderly people to live in their own homes rather than somewhere else, and this is a widely recognized phenomenon (Fernández-Caballero, Latorre, Pastor, & Fernández-Sotos, 2014). In particular, in China's reality, elderly people prefer to remain in their own homes than being hospitalized or because they tend to live in a relative familiar environment. However, for solitary elder people, once unexpected accidents happen, triggered by some chronic diseases or sudden illness, there is the problem of timely interventions and rescue. It is therefore particularly necessary to create home environments from the existing housing stock that are able to facilitate independent living (Barlow & Venables, 2004). Hence, “smart home” technologies can assist older adults to continue living at home with both safety and independence (Adair et al., 2013).
Smart homes are designed with the purpose of providing living spaces where interactive technologies and unobtrusive support systems can enable people to experience a higher level of independence, activity, participation or well-being than otherwise afforded (Morris et al., 2013). According to the systematic research of Morris et al. (2013), it can be learned that contemporary smart home technologies generally aim to perform different functions including tracking activities by various sensors, remote monitoring activated by voice etc.; they are versatile in functionality and are user friendly. However, in the endowment process, the elderly do not have only the physical needs, but also psychological needs.

In accordance with Maslow’s hierarchy of needs (McLeod, 2011), for individuals, once physiological needs are met, one’s attention turns to safety and security in order to be free from the threat of physical and emotional harm. Similarly, once a person has met the lower level physiological and safety needs, higher level needs become important, the first of which are social needs. Social needs are those related to interaction with other people and may include need for friend, need for belonging, and need for give and receive love (McLeod, 2011) (Figure 2).

![Figure 2. Maslow's hierarchy of needs (McLeod, 2011)](image)

Most of existing smart home designs focus on performing different functions packaged into friendly user interfaces, but emotional perspectives are scanty taken into account or are ignored. Hence the fundamental research question is “what physical and psychological needs of solitary elderly people in China should be addressed by an interactive smart home system?” In my thesis, the physical needs mainly come from health and security aspects, while the psychological part is mainly about the elderlies’ social life and relationships with their children and the needs in the higher levels of the Maslow’s pyramid.

In order to figure out this question step by step, some specific questions are defined as supports:

1. What is the current context of elderly solitaries’ lives in China?
2. What functions have been addressed by previous smart home designs for elderly?
3. What are the physical and psychological needs of Chinese solitary elderly people?

4. What are the attitudes of elderly to smart homes?

By answering the research questions, this thesis aims to explore the real demands of elderly people living alone in China in order to inform the design of smart home systems that satisfy both physical needs and psychological needs.

1.5 Thesis structure

The structure of this thesis is organized as follows:

Chapter 1: Introduction. In this chapter, I introduced the research motivation and research background in three aspects: social, cultural and technical aspects. After that, I give a description about my research question.

Chapter 2: Human-centred design of interactive systems. In this chapter, detailed explained descriptions and methods were presented by following the 5 steps of an entire human-centred lifecycle model. After that, there is a brief description about methods used in this thesis.

Chapter 3: The context in China. In this chapter, I presented the living context of elderly solitaries by the financial support, self-care ability, physical condition, and psychological status. In addition, a universal analysis of current living models of elderly in China is offered.

Chapter 4: State-of-art of smart home for the elderly. In this chapter, an analysis and comparison of existing smart home systems for the elderly was presented through the classification. Three modes are categorised including smart product assist mode; terminal, service centre, and service platform mode; and comprehensive environment intelligence mode.

Chapter 5: Research method. In this chapter, I explained in detailed about the research methods and research process in this thesis. It contains the theoretical framework (human-centred lifecycle model), and the data collection method (field interview).

Chapter 6: Interview results. In this chapter, I presented my interview results by group, and my requirement analysis based on the results.

Chapter 7: Discussion. In this chapter, I mainly came up with design proposal focusing on comparison between literatures and my findings.

Chapter 8: Conclusion. In this chapter, I presented an overall review and a brief summary of the thesis.
2. Human-centred design of interactive systems

Interaction design aims to solve problems between people and objects. There are many fields of interaction design, such as artist-design, industrial design, graphic design, etc. The definition of design from the Oxford English Dictionary captures the essence of design very well: “(design is) a plan or scheme conceived in the mind and intended for subsequent execution.” The process of design is also a process of balancing conflicting requirements (Jennifer, Yvonne & Helen, 2002). Hence, interaction design aims to develop a design that is informed by the intended use of a product, target domain, and empirical considerations (Sharp, 2003). According to Murray (2011), in a complete interaction design process, there are applied theories from related fields (Figure 3).

![Figure 3. Related Field of Interaction Design (Murray, 2011)](image)

The instrumental criteria to the success of an interactive system or a product are usability. For users, poorly designed and unusable systems mean difficult to learn and hard to operate. Systems are probable to be under-used, misused or disused with unsatisfied users keeping their recent working approaches; in order to maximize the usability, human-centred design (HCD) approach provides excellent methods for integrating the user perception into the software development process (Maguire, 2001).

According to ISO 9241-210 (2010), human-centred design is “an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, and usability knowledge and techniques, this approach enhances effectiveness and efficiency,
improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance”.

ISO 13407 (1999) standard explains the benefits achieved by making the interactive systems lifecycle more human-centred, and describes the processes required to make a human-centred design lifecycle. It lists four principles of HCD and four HCD activities (Table 1).

Table 1. Principles and activities of HCD (ISO 13407,1999)

<table>
<thead>
<tr>
<th>Principles</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active involvement of users</td>
<td>Understand and specify the context of use</td>
</tr>
<tr>
<td>Appropriate allocation of function to system and to user</td>
<td>Specify user and organizational requirements</td>
</tr>
<tr>
<td>Iteration of design solutions</td>
<td>Produce more than one candidate design solution</td>
</tr>
<tr>
<td>Multi-disciplinary design</td>
<td>Evaluate designs against requirements</td>
</tr>
</tbody>
</table>

“Active involvement of users”. Maguire (2001) points out that one superiority of using human-centred design is the active involvement of users who have relevant knowledge of the context in which the system will be used. This approach aims, thus, to enhance the acceptance of and the commitment to the new software.

“Appropriate allocation of function to system and to user”. Determining which aspects of a job or task should be operated by people and which can be handled by software and hardware is very significant (Maguire, 2001).

“Iteration of design solutions”. The purpose of this operation is to obtain feedbacks from end-users in the process of design and for further design (ISO 13407, 1999). Martin Maguire (2001) said these feedbacks might range from paper mock-ups to prototypes with greater fidelity.

“Multi-disciplinary design”. For a system, every user is a different individual; each user definitely has his or her own insights and expertise. The development of a human-centred system is a cooperative procedure benefiting from the active participation of diverse parties (Maguire, 2001).

As the work on ISO 13407 (1999) progressed, a formal model was also proposed, namely human-centred lifecycle model (HCI International, 2011). According to the HCI International (2011), there are five essential processes that should be undertaken in order to incorporate usability requirements into the software development process and the cycle will be repeated until particular usability objectives have been attained (Figure 4).
Figure 4. Design activities in the human-centred design process for interactive system (ISO 13407, 1999)

Conventionally, the basic principles of HCD entail the central and participative role that the user should play in an iterative design process as well as the identification of user-specific factors to guide and assess the design (Eggen, van den Hoven, & Terken, 2014). The HCD principles can therefore be used to elicit human factors and requirements that are relevant for the systematic design of smart homes. Unfortunately, elderly people living alone are in a special social group; the users cannot express their exact needs clearly and comprehensively. However, in the case of smart home, the user interaction with the system has many facets, from physical abilities to personal values, goals, needs, and pleasures, and all of these should be taken into account in the design. Therefore, in order to maximize the design of smart home for Chinese solitary aging people, the human-centred design lifecycle model is chosen as the theoretical framework.

2.1 Identify need for human-centred design

A significant issue in the design of usable applications is to know about the people who will be users, because different kinds of users require different types of interfaces (Johnson, Johnson, & Zhang, 2005). Designers cannot be knowledgeable about every type of users they design for; users are a valuable source of primary information in assisting designers to understand the real needs for the design of products and to ensure commercial success (Bruseberg & McDonagh-Philp, 2001). In order to be successful throughout the whole system development process, the first step must be carefully planned and managed. Maguire (2001) suggests a method for identifying the needs in this phase (Table 2).
Table 2. Method for identifying needs of human-centred design (Maguire, 2001)

<table>
<thead>
<tr>
<th>Method</th>
<th>Usability planning and scoping</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approach of method</td>
<td>Meeting with key stakeholders</td>
</tr>
<tr>
<td>Objective</td>
<td>Collecting information about:</td>
</tr>
<tr>
<td></td>
<td>Why is the system being developed?</td>
</tr>
<tr>
<td></td>
<td>What are the overall objectives?</td>
</tr>
<tr>
<td></td>
<td>Who are the intended users and what are their tasks?</td>
</tr>
<tr>
<td></td>
<td>Why will they use the system?</td>
</tr>
<tr>
<td></td>
<td>What key functionality is needed to support the user needs?</td>
</tr>
<tr>
<td></td>
<td>What are the usability goals? (How important is ease of use and ease of learning?)</td>
</tr>
</tbody>
</table>

2.2 Understanding and specify the context of use

Context is an important concept. The term “context-aware” was published in 1994 by Schilit and Theimer (1994) who defined context as “location, identification of nearby people and objects, and changes to those objects”. Pascoe (1998) defined context to be “the sub-class of physical and conceptual states of interest to a particular entity”. This definition is too specific. Context should include all things relevant to a product or a system and their users. But with the development of the field, the definitions become closer to the true spirit of context. Dey (2001) defined context as “any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves”.

According to ISO 13407 (1999) standard on human-centred design, the context of use is constitutive of “users, tasks, and equipment (hardware, software and materials), and the physical and social environments where a product is used”.

Context of use is important in the design because the quality of using a system relies on the level of understanding of the context of use of the system (Maguire, 2001). Three methods used in this phase are suggested including (1) identify stakeholders (Taylor, 1990), (2) context-of-use analysis (Thomas & Bevan, 1995) and (3) survey of existing users (Preece et al., 1994) (Table 3).

Table 3. Comparison between three methods of analyzing the context-of-use (Maguire, 2001)

<table>
<thead>
<tr>
<th>Method</th>
<th>Activities</th>
<th>Approach of methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identify stakeholders (Taylor, 1990)</td>
<td>Lists relevant users and stakeholders to make sure that none of them is excluded during system design.</td>
<td>Meeting held with project managers and user representatives.</td>
</tr>
<tr>
<td>Context-of-use analysis (Thomas &amp; Bevan, 1995)</td>
<td>Provides background (context) information against which design and evaluation take place.</td>
<td>Meeting with representatives from both user groups and design teams.</td>
</tr>
</tbody>
</table>
2.3 Specify the user and organizational requirements

The need to focus on users is emphasized throughout the whole process. However, the concept “stakeholder” is sometimes confusable with the concept “user”. Holtzblatt and Jones (1993) summarize their definitions of “users” by including those individuals “who manage direct users, those who receive products from the system, those who test the system, those who make the purchasing decision, and those who use competitive products”. Stakeholders are defined as “people or organizations who will be affected by the system and who have a direct or indirect influence on the system requirements” (Sommerville & Kotonya, 1998). Hence, generally speaking, the group of stakeholders for a product is larger than the group of users and at the same time it includes the users (Sharp, 2003).

Maguire (2001) point out that there is a widely accepted opinion that requirements elicitation and analysis are the most critical segments of software development; the success of a software development program can basically depend on how well this activity is experimented. According to Khan, Dulloo, and Verma (2014), a requirement is defined as a description of what a system is designed and realized to do in software engineering field. It plays an essential, decisive, and directional role in the process of constructing a system for keeping in view of stakeholders. Requirements elicitation is the procedure of discovering, obtaining, and collecting requirements by communications with the stakeholders (Pandey & Mustafa, 2010).

In the systematic review of requirement elicitation conducted by Khan et al. (2014), they listed five common requirement elicitation techniques, which are interviews, questionnaires, observations, documents analysis, and prototyping. Interviews, observation and documents analysis are usual methods used in qualitative research. Prototyping method can be selected when there is a mass of uncertainty about requirements, or when early response is needed from stakeholders (David, 1992). Interview is typical conversational traditional method most generally used since it is fundamentally human based social activity, and an efficient approach for data gathering (Sharma & Pandey, 2013).

ISO 13407 (1999) provides a general guidance on specifying user and organizational requirements. This states that the following elements should be covered in the specification.

- Identification of the range of relevant users and other personnel in the design.
- Provision of a clear statement of design goals.
- An indication of appropriate priorities for the different requirements.
- Provision of measurable benchmarks against which the emerging design can be tested.
- Evidence of acceptance of the requirements by the stakeholders or their representatives.
- Acknowledgement of any statutory or legislative requirements.
- Clear documentation of the requirements and related information. Also, it is important to manage changing requirements as the system develops.
2.4 Produce design solutions

There are many ways for design solutions including some common methods like reasonable improvement from prior studies and creative solutions. Whatever the original source, iterative development is inevitable for all design ideas (Maguire, 2001). ISO TR 18529 (2000) summarizes good practice activities for producing design solutions in the lifecycle as follows (Table 4).

Table 4. Design solutions process according to ISO TR 18529 (2000)

<table>
<thead>
<tr>
<th>Activities</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocate functions</td>
<td>Transfer needs and requirements into specific functions and specify a clear system boundary.</td>
</tr>
<tr>
<td>Produce composite system model</td>
<td>Integrate the allocated functions into a composite system.</td>
</tr>
<tr>
<td>Specify system and use</td>
<td>Specify system details including technical support, interaction type and so on.</td>
</tr>
<tr>
<td>Develop prototypes</td>
<td>Develop software structure and screen layouts on paper. Select appropriate users to do assisted test in controlled or less formal setting.</td>
</tr>
<tr>
<td>Iterate</td>
<td>Make relevant modification according to assisted evaluation.</td>
</tr>
</tbody>
</table>

2.5 Evaluate designs against requirements

Nielsen (1992) states that for a typical user experience, the primary need is to meet users’ exact needs without fuss; then producing products with simplicity and elegance, which are a joy to own and use. In order to ensure the usability of outcome, evaluation process is essential and it is driven by questions about how well design or particular part satisfies users’ needs and offers appropriate user experience.

According to Nielsen (2012), usability is defined by five quality components and can be described as follows (Table 5).

Table 5. Usability components (Nielsen, 2012)

<table>
<thead>
<tr>
<th>Usability components</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learnability</td>
<td>“Perceived ease of use. How easy is it for users to accomplish basic tasks the first time they encounter the design?”</td>
</tr>
<tr>
<td>Efficiency</td>
<td>“Perceived Usefulness. The time it takes to complete tasks. Once users have learned, how quickly can they perform tasks?”</td>
</tr>
<tr>
<td>Memorability</td>
<td>“When users return after a period of not using it, how easily can they reestablish proficiency?”</td>
</tr>
<tr>
<td>Errors</td>
<td>“How many errors do users make, how severe are these errors, and how easily can they recover from the errors?”</td>
</tr>
<tr>
<td>Satisfaction</td>
<td>“User comfort and acceptability. How pleasant is it to use the design, how does it meet the exact needs of users?”</td>
</tr>
</tbody>
</table>

In order to figure out whether usability requirements have been achieved, tasks could be delivered to users based on operating the systems. Maguire (2001) addressed that observing the user-based evaluations on the usability is the most effective to reveal genuine problems of systems. According to his research, there were fundamentally three levels of formality when conducting evaluation processes, which were participative
evaluation (to obtain users’ opinions about impression of screen designs, their expectation, and what kinds of improvements could be suggested), assisted evaluation (to obtain the maximum feedback and maintain the authenticity by inviting users to perform tasks and express their insights) and controlled evaluation (to figure out how successful users will be with the full working system in the test environment).

2.6 Brief description of approach selection

For the reason that there are many approaches available for each stage of the whole human-centred lifecycle model, in this section, I would like to give a brief description introducing the methods used in my thesis. More precise interpretation is presenting in the chapter of research method.

The first stage is identifying need for design using the method suggested in section 2.1 through searching answers for relevant specific questions in both literatures and real situations. This stage is presented in Chapters 1 and 2.

The second stage is to understand and specify the context of use. A context-of-use analysis suggested in section 2.2 is presented to specify the financial support, self-care ability, physical condition, psychological status, and the living models of the elderly in China. The main findings at this stage are presented in Chapters 3, 4, and 6.

The third stage is to specify the user requirements. A literature review on previous smart home modes for the elderly is exhibited and field interviews are experimented for requirements elicitation. Requirements are finalized by integrating prior studies and the interview data analysis. What to be noticed is that, the requirements are specified mainly from the psychological and physical needs, technical details are not in the scope. The main findings are presented in Chapter 4 and Chapter 6. A comparison of literature findings in Chapter 4 and empirical findings in Chapter 6 is presented in Chapter 7.

The subsequences are producing design solutions and evaluation against the requirements. However, in this thesis’ scope, the core target is to dig the physical and psychological requirements, the rest segments will not be realized for now because of the workload and time limitation.
3. The context in China

3.1 Elderly people living alone

Elderly people living alone (solitary people) mentioned in this thesis refer to the aging people who are more than 60 years old living alone (the reasons why they live alone may be widowed, divorced or separated). According to a report of Li et al. (2006), compared with elderly people who live with their spouses, elderly solitaries relatively have worse psychological status; more than a quarter of elderly people living alone often have loneliness and other negative feelings. Therefore, in this thesis, those aging people who have spouses or children as companions are not taken into account.

In accordance with the data statistics conducted by Gao, Yan, & Ji, (2012) and Zhong (2004), it can be concluded that:

- Generally elderly people living alone have low income, which is mainly from old-age pension (Figure 5). According to Baidu Baike (2015), the average monthly pension of Chinese elderly people who are retired is approximately 2000 Yuan (about 285.7 Euros).

- Even though more than a half people can completely take care of themselves, there are still approximately 41% of them having the need to be nursed (Figure 6).

- Their general physical condition is ordinary and poor, thus certain knowledge of health care is required (Figure 7).

- The majority of elderly people living alone have obvious loneliness and other kind of negative feelings (Figure 8).

![Financial support](image)

**Figure 5.** Financial support statistics (Gao et al., 2012)
3.2 Living models of the elderly

In recent years, some provinces and cities in China have made active exploration and useful attempt in terms of the diversification of endowment models for elderly solitaries. According to Gao et al. (2012), the domestic situation of the endowment could be mainly divided into four patterns, which form a social network combining society, community and family. The four patterns consist of home endowment, family endowment, institution (or community) endowment, and day-care endowment (Table 6).
Table 6. The classification of domestic endowment patterns (Gao et al., 2012)

<table>
<thead>
<tr>
<th>Patterns</th>
<th>Main objects</th>
<th>Contents</th>
<th>Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home endowment</td>
<td>Empty nesters or elderly people living alone.</td>
<td>The elderly have the abilities of taking care of their daily lives. Community offers some services such as medical care, spiritual consolation and etc.</td>
<td>The elderly are living at their own homes, community and other institutions provides hotlines or other alternatives to satisfy their extra needs.</td>
</tr>
<tr>
<td>Family endowment</td>
<td>Predominantly rural elderly population.</td>
<td>The livelihood of the elderly is maintained by the supplement of necessities and food from their children.</td>
<td>The elderly are living with their children or near their children. Long-term nursing care based on kinship ties of families.</td>
</tr>
<tr>
<td>Institution (or community) endowment</td>
<td>Elderly people living alone.</td>
<td>Apartments, nursing homes for the elderly and other similar institutions provide full range of care and services.</td>
<td>The elderly are living in professional institutions. There are professional staffs with specialized skills providing professional services and care both in physical and mental.</td>
</tr>
<tr>
<td>Day-care endowment</td>
<td>Elderly people living alone (especially those who have obstacles in taking care of themselves).</td>
<td>The elderly spend their day time (or half a day) in day-care centres or other institutions, then they are escorted to their own homes at night.</td>
<td>The elderly are living at their own homes at night, and living in day-care centres in daytime. There are special staffs responsible for morning and evening shuttle. Nursing and meals are offered with relative low prices.</td>
</tr>
</tbody>
</table>
4. State-of-art of smart home for the elderly

The concept smart home is also known as automated home or intelligent building, which is a homelike environment whose features are automated and the devices can communicate with each other (Ricquebourg et al., 2006). More than that, a set of sensors gathers different kinds of data, regarding the actions and behaviours of inhabitants, and then after analysing, computers or devices will respond by controlling certain mechanisms that are built in to the home (De Silva, Morikawa & Petra, 2012). Smart home technology makes it possible that computers and devices can interact with residents. It has been decades since the proposal of smart home; various smart home systems and products have been developed. De Silva et al. (2012) classified smart home types by expected design objects (Figure 9).

![Figure 9. Smart home classification according to De Silva et al. (2012)](image)

4.1 The existing smart home modes

With the increasing trend of aging population, smart homes for elderly people have become very popular and essential. They are intended to create an assistive and safe environment beyond comfort and leisure. In order to present the existing situation of smart homes for elderly, I would like to classify them into three different types as follows.

4.1.1 Smart product assist mode

Smart home products are intelligent artifacts, which contribute to a better life in terms of safety, healthy, happiness, convenience, efficiency, etc. What many of the smart home products for the old have in common is that they are designed with the purpose of bring more convenience and safety to their lives.

“The Aid” designed by Egle Ugintaite is a smart cane with only two buttons that provides both mobile navigation and health management services to those elderly people who have
obstacles in walking independently (Designboom, 2011). From the aspect of the design, it is mainly dedicated to help people as a real “helping hand”. As a navigator, it guides and prevents users from getting lost. As a service and health device, it has a LED monitor showing up information in regards to user’s pulse, blood pressure, and temperature. What is more, by pressing the SOS button when help is needed, it will automatically contact the help center and send the current health data and location of user’s to make sure they could have immediate and qualified help (Figure 10).

![Image of the Aid walking cane](image1.png)

**Figure 10.** The Aid walking cane (Designboom, 2011)

“Easy Pill” is designed by Chung-yen Chang, Surya Bhattacharya, Tahsin Emre Eke, and Yuhang Yang as a solution for organizing pills (Tuvie, 2013). It is an intuitive medical system integrating a pill organizer “Pillpad” with the medical database and App. Doctors and pharmacists or even families can set up the schedule for taking pills by using the App, so that elderly user are able to take the right pills at the right time independently by the notification of the digital clock and light (Figure 11, Figure 12).

![Image of the Pillpad of Easy Pill](image2.png)

**Figure 11.** The Pillpad of Easy Pill (Tuvie, 2013)
The strengths of these auxiliary smart home products for elderly are that they are easy to carry-on and targeted. They are designed to propose specific solutions for certain characteristics of the elderly population such as subjects with motor, visual, auditory or cognitive disabilities. However, at the same time, there is inevitable lack of systematic smart home endowment services, leading to a situation that various requirements cannot meet by a single product in a time. User needs to purchase multiple relatively independent products if he or she has multiple demands, as a consequence, it will definitely follow with recognition and economic burden. Consequently, those elderly people who have significantly single demand and are physically well-being could be target user of smart product assist mode.

4.1.2 Terminal, service centre, and service platform mode

This mode is a typical endowment model that integrates system with contextualized service and concentrates on the organization of the services. System gathers daily physiological indexes such as basic health indicators of the elderly through the terminal sensors, then, service center receives the signal to make a transit judgment, if any abnormal vital sign is detected, a deployment decision will be executed by service center to contact hospitals, the third-party service providers or relatives. From the aspects of end users, the service platform is hidden; they probably not have the direct contact with the platform. Deen (2015) considers this kind of mode is an efficient and cost-effective solution to the problem of elderly and patient care; remote healthcare monitoring at home is better than in nursing homes or hospitals because of the limited spaces and expensive cost.

A schematic diagram of an autonomic smart home architecture presented in (Deen, 2015) is showed in Figure 13. It illustrates the significant stakeholders of this mode. On body sensor plays a role of detecting; medical center could monitor, analyze, plan, and execute by receive data through the Internet.
A successfully tested multimedia smart home platform has been developed in Spain to support patients who need specific health care at home. According to the description presented by Chan, Estève, Escriba, and Campo (2008), the platform system consists of two components. The first part is the home terminal, which is composed of a videoconferencing-data processing module and a recording module for vital signs. Data gathered from terminal sensors are transmitted to a computer for analyzing. The second part is the caregiver’s medical center, a call center, and one or more medical workstations are included. The subsequences are performed by the medical center workstation such as video conferencing with a doctor, and medicine prescription.

The strength of this mode is that there are systematic services for the elderly, which involves multi-stakeholders. Besides, the platforms offer an opportunity for users to exchange experiences with social world. The obvious weakness is that, the usability and interaction design of terminal product is not decent, comparing with specific smart home product. Therefore, those elderly people who have the demand of nursing and the desire of communicating with outside could be target users of this mode.

4.1.3 Comprehensive environmentally intelligent mode

A comprehensive smart home is constituted by a set of applications, where the environment is monitored by ambient intelligence to provide context-aware services and facilitate remote home control; it involves incorporating smartness into dwellings for comfort, healthcare, safety, security, and energy conservation (Alam, Reaz & Ali, 2012) (Table 7).

This kind of integrated mode is capable of providing more natural interactive experiences for the elderly and reducing cognitive load at the same time. Nevertheless, the implementation of this type has a high demand of technology unity, not only the adoption of optimised algorithms but also the deployment of assistive sensors and products.
Table 7. Summary of a comprehensive smart home according to Alam et al. (2012) and Chan et al. (2008)

<table>
<thead>
<tr>
<th>Object</th>
<th>Description</th>
<th>Common functionalities</th>
</tr>
</thead>
</table>
| Comfort | The increment of user comfort is a main object that can be achieved in two aspects. One is human activity identification and event automation in local. The other is remote home management distantly. | 1. Lighting subsystem: Intelligent lighting controls to adjust the lighting effects of different living areas and different occasions. E.g. the light in a room will be automatically turned on when detecting someone is entering the room.  
2. Temperature control subsystem: Self-adjusting temperature and ventilation depending on weather and demand. |
| Healthcare | Healthcare facilities are provided for patients, elderly people, and healthy people. Healthcare services can be provided on-site to generate health support locally and be remote provided for emergency support. | 1. Health monitoring subsystem: Real-time monitoring of physical and living situation of older individuals through the terminal sensors. E.g. wearing smart wearable devices to monitor vital signs in daytime, and at night, sensors beside the bed will continue to detect sleeping state and physical condition.  
2. Medical assistant subsystem: Automatically or personally contact caregiver and medical assistant provide when emergency happens. E.g. if a fall is detected by the floor detector, and an abnormal sign is captured by the wearable device, the SOS information will be immediately sent. |
| Security | Smart homes are vulnerable to security threats; security problems could be caused both locally and remotely. For example, burglary and hacker attack. | 1. Security subsystem: Firewall and virus-protection software and taxonomy of common security threats according to product functionality.  
2. Alarm subsystem: Sensors are settled in windows and doors, when unexpected house breaking happens, alarm sounded and security personnel will be informed. |

A full range of cares and low cognitive load is characteristic of this mode. The environmentally intelligence mode makes contribute to natural interactive experience between the old and the entire system. Generally speaking, the user is in a passive state so that they do not need to be familiar with many complicated operations. However, the apparent drawback is the expensive cost for purchase, installation, and maintenance. Therefore, those elderly people who can afford the cost and have the demand of all-around care could be target users of this mode.

4.2 Acceptance of smart homes

In 2003, the population of elderly had already been in a rapid growth, how to live independently was a critical issue; several pilot smart home projects were experimented such as SmartBo project in Sweden for elderly care. In order to investigate old adult’s attitudes towards and perceptions of smart homes, Demiris et al. (2004) did a pilot study in a population of retired and well-educated old people from the upper middle-class income bracket. Their survey concluded that all participants had a positive attitude towards smart home technology and were willing to accept the installation of sensors and devices in their homes. In a new study, Morris et al. (2013) made a conclusion that for elderly adults, their family members, and healthcare professionals, available smart-home technologies are readily acceptable.
Later in the spring of 2015, Icontrol Network (2015) did a survey in the United States and Canada including 1600 consumers. Based on the results, they reported the adoption indicators and examined attitudes of consumers towards the smart home. According to the report, the top three ways, which are currently used by families for keeping trace of their parents and grandparents, are check-ins over the phone (55%), in person (37%), and by email (23%). Approximate 50% of all consumers say that if their parents or grandparents had a smart home, they would sleep better at night, not only that, about 72% of consumers who aged 25-34 have the same positive attitude. On the other side, concerns are collected such as the cognitive burden for training of new technology, privacy violation, user-friendliness, and lack of human responders.

These researches had inevitable limitations. The area they research, the race they survey, the age and sex distribution, the economic status and the educational level of samples, these factors will definitely have influence on the final results. However, it is undeniable that the majority of people have interest in smart home technology for elder care; they are not reluctant to live in an affordable smart home. The acceptance and expectancy are playing vital roles in the promotion of elder care smart home field.
5. Research method

The fundamental research question is “what physical and psychological needs of solitary elderly people in China should be addressed by an interactive smart home system?” In order to figure out this question, some specific sub-questions are defined as supports: 1) What is the current context of elderly solitaries’ lives in China? 2) What functions have been addressed by previous smart home designs for elderly? 3) What are the physical and psychological needs of Chinese solitary elderly people? 4) What are the attitudes of elderly to smart homes? For answering questions 1 and 2, I did literature review on prior studies in Chapters 3 and Chapter 4. For answering questions 3 and 4, I conducted field interviews in three different groups. In addition, empirical findings obtained via the interviews inform also the context of use of potential smart home designs. Moreover, the literature review findings on smart homes state-of-the-art are also utilized for specifying the final requirements.

The whole research process is framed within human-centred lifecycle model. In the followings, I described my research process and my entire interview research procedure.

The theoretical framework of this thesis is human-centred lifecycle model. Technically, there are five compulsory stages for completing the whole process arranged from a plan to a working artifact. However, the purpose of this thesis is to identify requirements that form the basis for further development of a smart home system. The subsequence after specifying requirements will not be in the scope of the thesis.

The research procedure obeys the human-centred lifecycle model steps until completing requirements specification work (Table 8).

<table>
<thead>
<tr>
<th>Research stage</th>
<th>Relevant chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Identify needs of HCD</td>
<td>Chapter 1 and Chapter 2</td>
</tr>
<tr>
<td>2. Understand and specify the context of use</td>
<td>Chapter 3, Chapter 4, Chapter 6</td>
</tr>
<tr>
<td>3. Specify user requirements</td>
<td>Chapter 4, Chapter 6 (discussion in Chapter 7)</td>
</tr>
</tbody>
</table>

5.1 Qualitative research

5.1.1 Method selection: Interview

A general purpose of qualitative research is to understand people by what they say and do. There are three common data gathering techniques: interviewing, participant observation, and using existing materials (Taylor, Bogdan & DeVault, 2015). Considering that my aim is to explore the current needs of elderly solitaries in China, data from literature review is insufficient and outdated; hence, field interviews are conducted to focus on the subjects’ world. The reason why choosing interview instead of questionnaire is the target population may have diminution of vision and other similar physical problems. In addition, because all questions and options in a questionnaire are pre-determined, investigators cannot do a comprehensive analysis of all the problems and possible answers, it will inevitably miss the complexity and subtlety of respondents even though the results may be extensive. Therefore, interview mode is selected to gain insights and
requirements from users. During the interviews, I aim to explore their feeling of their existing endowments and expectation for smart home endowments by digging factors that influence the satisfaction. Then, the specification of the exact requirements combines the interview results and literature review on historical smart home design.

There are three types of interviews: Structured interview, unstructured or semi-structured interview, and group interview (Myers, & Newman, 2007). They gave explanation about each kind. A structured interview means there is a complete and prepared script, there is no room for improvisation. However, during an unstructured or semi-structured interview, the researcher could have prepared questions beforehand, and there is a need for improvisation. In a group interview, there are two or more interviewees at a time. This type can be structured or unstructured. Considering that most elderly people living alone are emotional sensitive, and easy to arouse negative emotions, in order to have smooth interviews, flexible and unstructured interviews are suitable for this survey.

5.1.2 Interview objects and outline

Interviews are conducted to discover understanding of a particular group (DiCicco-Bloom & Crabtree, 2006). Interview objects are those who provide direct data during the interviews. The selected interviewees should be standardized and have critical similarities in common related to the research question (McCracken, 1998). My interviews focus on the study of elderly people living alone, a special type of social groups, with emphasis on mining depth and the importance of the rich diversity of information. Nielsen (2000) addressed that from his previous research, 15 test users are needed to discover 100% usability problems, but 3 studies with 5 users each is more effective than 15 representative users.

For the purpose of digging potential requests and maximize the richness of data, in this thesis, interviewees are identified by a multistage method by the reference of survey conducted by Icontrol Network (2015), which did the investigation contained people arranged from children generation to parents generation. The first category is direct users including both elderly people living alone over 60 years (group one) and those who are 50-60 years old (group two) will become elderly in the next decade. The second category is indirect users: children of elderly solitaries (group three)(Figure 14).

![Diagram of Interview Objects](image-url)

**Figure 14.** The interview objects.

On account of my previous summary on smart home characteristics in Chapter 4 and the research purpose, in-depth investigation on existing elderly solitaries covers five main topics: 1) basic information about interviewees, 2) daily life, 3) health care, 4) emotional communication, and 5) smart home. Table 9 presents the interview outlines.

By analyzing the problems and needs of today's home endowment, reasonable and systematic home care service can be proposed. At the same time, the elderly between
50-60 are instrumental objects in this study for the reason that their lives, habits will definitely indicate the development direction of smart home for elderly in the next decade. Meanwhile, children plays a vital, irreplaceable role in their elderly parents’ lives, the harmonious degree of their relationship will largely affect the psychological well-being of the elderly. Hence digging their insights is essential.

On the basis of interview outline, I prepared an interview plan for relative detailed coverage (See Appendix A). For all groups, the background information and their knowledge, experience and insights about smart home are essential. For group 1, the specific questions are in the scope of health condition, living environment, behavior rules, social life, expectation and demand for living independently. For group 2, the specific topics are about behavior rules, social life, and expectation and demand for living independently. Health condition and living environment are not taken into consideration for group 2. The specific questions for group 3 are mainly about the obstacles in interacting with their parents and expectation for smart home. In addition, I planned to introduce the three common modes of smart home summarized in Chapter 4 no matter my interviewees have the experience about smart home or not, I prepared some pictures about above three modes for more vivid description.

Table 9. Interview outlines

<table>
<thead>
<tr>
<th>Interview objects</th>
<th>Content outlines</th>
</tr>
</thead>
</table>
| Elderly solitaries over 60               | 1. To know their basic information, behavior rules, social life, and the relationship with children and their needs and expectation for home endowment.  
2. To know their health condition, financial support, living condition.  
3. To explore their attitude, needs and expectations for smart home service. |
| Elderly between 50-60                    | 1. To know their basic information, behavior rules, social life, and the relationship with children and their needs and expectation for home endowment.  
2. To observe their interaction with smart devices (For example smart phone.)  
3. To explore their attitude, needs and expectations for smart home service.  
4. Make comparison between them and elderly solitaries over 60. |
| Children of elderly solitary             | 1. To know the relationship with their father or mother.  
2. To know their support methods to their parents.  
3. To explore their obstacles in interacting with parents  
4. To explore their attitude and expectations for smart home service |

5.1.3 Interview environment

Interviews were conducted in the city of Xiamen, a Chinese coastal city. Xiamen was ranked as China’s second “most suitable city for living” in 2006 and China’s most romantic leisure city in 2011 (Daily Xiamen, 2011). It is a typical tourist industry driven city; the majority of work-age adult people immigrate to first tier cities for better development, which prompt a high proportion of elderly solitaries. According to Zhou and Xi (2015), China entered the aging society in 1999, while Xiamen started to enter the aging society in 1994, 5 years earlier than the average level; and at the end of 2011, the sum of elderly solitaries occupied 50% of all the elderly over 60 years old.
The campus of Xiamen University was selected as the fixed location for interviews. There are two reasons for choosing the university campus. First, Xiamen University campus is one of the famous tourist attractions in that city for the scenic beauty, as long as the weather is nice, there are many elderly people enjoying the scenery in campus, interview objects are concentrated. Second, according to my investigation, a lot of retired older employees of university are living in faculty apartments, which are inside the campus; their levels of education and income are relatively high, that is benefit for me to carry out in-depth communication.

5.1.4 Interview data collection and analysis

Audiotape recording, videotape recording and note taking are methods used for recording interview data for documentation, the most frequently used approach is recording with tape-recorder (DiCicco-Bloom & Crabtree, 2006). In my research, all the interviews were experimented in Chinese Mandarin. In order to keep effective in the process of transcribing interviews data into text, I did both audiotape recording and note taking throughout all interviews. For the purpose of fast recording and data classification, I extended my interview plan to three copies of detailed question list for each group (see Appendix B: question list for group 1).

In the preparation procedure for interviews, I sorted the question list according to the importance of data priority with the hope that the interview can be preceded as I expected. But actually, all interviews were conducted more naturally than planned. I always started the conversations with some normal topics for minimizing the embarrassment, such as what a nice weather today. And then, some of my interviewees were initiative to talk about their daily life and their family with my leading. After a while, I presented my purpose and asked questions that had not covered in previous talk to collect needed data. During interviews, I kept writing down corresponding answers to question list. After each interview, I reorganized all useful information by integrating note and tape record and filled the text in each question list document. In order to avoid privacy violation, the interview information and results are presented anonymously by replacing their true names.

The most difficult and most crucial aspect in this thesis is analyzing interview data for requirements collection. The reason why data analysis is universally regarded as arduous is that it is a dynamic, intuitive and innovative activity instead of a fundamentally mechanical or technical activity (Basit, 2003). Even though coding and analysis are not identical, coding is indeed a common method for carrying out conclusion in qualitative researches. Coding or categorizing date involves two weighty activities, which are subdividing the data and assigning categories (Dey, 2003). I assigned three categories (i.e. basic information, living environment, attitude to smart home) and corresponding sub-categories for coding interview data. Table 10 is a template that will be used throughout the whole coding process. However, what need to be claimed is that coding process was not carried out in full accordance with the template because of existence of unpredictable information.
Table 10. No.0: Mr. X, living alone for xx years

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Age:</th>
<th>For all groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender:</td>
<td></td>
<td>For all groups</td>
</tr>
<tr>
<td>Education:</td>
<td></td>
<td>For all groups</td>
</tr>
<tr>
<td>Income per month:</td>
<td></td>
<td>For all groups</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living environment</th>
<th>Health condition:</th>
<th>For group 1 only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Living condition:</td>
<td></td>
<td>For group 1 only</td>
</tr>
<tr>
<td>Behavior rules:</td>
<td></td>
<td>For group 1 &amp; 2</td>
</tr>
<tr>
<td>Relationship with children/parents:</td>
<td>For all groups</td>
<td></td>
</tr>
<tr>
<td>Social life:</td>
<td></td>
<td>For group 1 &amp; 2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitude to smart home</th>
<th>Does he/she have smart device?</th>
<th>For group 1 &amp; 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>What is his/her attitude to smart home?</td>
<td>For all groups</td>
</tr>
<tr>
<td></td>
<td>Does he/she have knowledge/experience of smart home systems and devices?</td>
<td>For all groups</td>
</tr>
<tr>
<td></td>
<td>In above three modes, which one does he/she prefer? Why?</td>
<td>For group 1 &amp; 2</td>
</tr>
<tr>
<td></td>
<td>What are the concerns and expectations about smart home?</td>
<td>For all groups</td>
</tr>
</tbody>
</table>
6. Interview results

The interview results obtained after data analysis have been translated and documented into textual data in English categorized by individual in this chapter.

6.1 Group One: elderly solitaries over 60

For group one, I interviewed 8 elderly individuals randomly in the campus. It is worth mentioning that one of them can understand Mandarin, but only speak the local dialect – Hokkien; hence, I gave up this object because of incomprehension for that dialect. Eventually, there are 7 interviews valid in total. Since three of them are in a high rate of similarity, five representatives are elected in the end for summarizing their requirements.

Tables 11-15 present the summary information.

**Table 11. No.1: Mrs. A, living alone for more than 15 years**

<table>
<thead>
<tr>
<th>Basic information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age: 79</td>
</tr>
<tr>
<td>Gender: Female</td>
</tr>
<tr>
<td>Education: High School</td>
</tr>
<tr>
<td>Income per month: Pension (3000 yuan)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living environment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Health condition:</strong> No serious disease, no chronic disease. No medicine, but one piece of Vitamin tablet and calcium tablet per day. No periodic physical examination. No measures for emergency.</td>
</tr>
<tr>
<td><strong>Living condition:</strong> Housework and cook all by herself. Live in the fifth floor, no elevator. Shops for food and living necessity are close.</td>
</tr>
<tr>
<td><strong>Behavior rules:</strong> Sleep for about 6 hours, but not deeply. Get up at 6 am. Watch TV and take a walk in leisure time.</td>
</tr>
<tr>
<td><strong>Relationship with children:</strong> Four children, three of them are in other cities. Almost all children including grandchildren make phone calls at least once a week, but rarely meet.</td>
</tr>
<tr>
<td><strong>Social life:</strong> Friends are living far away; she meets with friends only when necessary.</td>
</tr>
</tbody>
</table>

**Attitude to smart home**

She does not have any smart device.

She has a positive attitude to smart home.

She has a smart camera in her house brought and set by her son so that their children can see her and her house by connected application. But that is one-way connect, she cannot see her children’ vision.

In above three modes, she prefers “terminal, service center and service platform mode”. Because she thought it is not expensive and reliable.

What she worries about smart home is that she is unable to use. If there is any problem with software setting or devices themselves, she will have no idea about dealing those problems.
Table 12. No.2: Mrs. B, living alone for about 2 years.

| Basic information | Age: 75  
|                  | Gender: Female  
|                  | Education: Bachelor Degree  
|                  | Income per month: Pension (7000 rmb)  
| Living environment | Health condition: Crus varicosity (she cannot walk or stand for a long time, so she has a crutch). No medicine. One periodic physical examination a year. No measures for emergency.  
|                  | Living condition: Live in the third floor, she will be dizzy when using elevator, so she always climb stairs. She has an hour-paid maid for house clean and laundry (once a week). She cooks lunch and dinner, but buys breakfast directly. Shops for food and living necessity are very close.  
|                  | Behavior rules: Sleep for about 4 hours, and not deeply. Wake up early but get up at 6 am. Watch TV, practice calligraphy and hang out with friends in leisure time.  
|                  | Relationship with children: Two children, daughter is in another city. They make calls to her about twice a week. She can meet with her daughter about a few days a year; her son will come to see her about once a month.  
|                  | Social life: Friends and previous colleague are living very close; she meets with friends frequently.  
| Attitude to smart home | She has a tablet computer; she thought the screens of smart phones are too small to read.  
|                  | She has a positive attitude to smart home.  
|                  | She did not heard about smart home before, but she thought the above smart cane is great. She thought “smart product assist mode” would be very useful and helpful. It can focus on single demand.  
|                  | She does not worry about the price, as long as devices are easy to use and useful.  

Table 13. No.3: Miss C, living alone for about 2 years

| Basic information | Age: 61  
|                  | Gender: Female  
|                  | Education: Middle School  
|                  | Income per month: Pension (3000 rmb)  
| Living environment | Health condition: She has a history of mental illness for many years, so she needs to take medicines all the time and visit doctors frequently (about once a week). There is a small community hospital downstairs. She has the symptom of hand tremble. No measures for emergency.  
|                  | Living condition: Housework and cook all by herself. Live in the third floor, no elevator. Because her brother lives in the fifth floor, so he always helps her with some housework. Shops for food and living necessity are close.  
|                  | Behavior rules: Sleep condition depends on her mental state, not stable. Get up at 6 am. Watch TV, take a walk and knit in leisure time.  
|                  | Relationship with children: No child. No marriage.  
|                  | Social life: She used to live with her mom. Because of the mental illness, she nearly has no friends.  
| Attitude to smart home | She has no smart device.  
|                  | She has a negative attitude to smart home.  
|                  | She did not show any interest in smart home, she thought it would be very expensive and useless to her.
### Table 14. No.4: Mr. D, living alone for more than 3 years

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Health condition: No serious disease, no chronic disease. No medicine, but one piece of calcium tablet per day. Periodic physical examination (once a year). No measures for emergency.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Living condition: Housework all by himself. Most of the time he has meals in the university canteen, sometimes he cooks. Live in the fifth floor, no elevator. Shops for food and living necessity are very close.</td>
</tr>
<tr>
<td></td>
<td>Behavior rules: Sleep for about 7 hours. Get up at 6 am. Normally he does exercises in the morning, reads or plays Chinese chess with friends in the afternoon, and watches TV in the evening.</td>
</tr>
<tr>
<td></td>
<td>Relationship with children: Two sons. One is in Canada; the other is in another city. They make calls about once a month.</td>
</tr>
<tr>
<td></td>
<td>Social life: Friends are living in the same community (university faculty apartment). He always plays chess and exercises with friends.</td>
</tr>
<tr>
<td>Attitude to smart home</td>
<td>He has a tablet computer for reading and watching TV, and he knows the basic operation of a laptop.</td>
</tr>
<tr>
<td></td>
<td>He has a high positive attitude to smart home. He thought smart home systems and services would be very useful.</td>
</tr>
<tr>
<td></td>
<td>In above three modes, he prefers “terminal, service center and service platform mode”. Because he thought it is and reliable to have a third-party service.</td>
</tr>
<tr>
<td></td>
<td>What he worries about smart home system is that data obtained by the sensors will be accurate or not and what is the probability of misjudgment.</td>
</tr>
</tbody>
</table>

### Table 15. No.5: Mr. E, living alone for more than 5 years

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Health condition: No serious disease, no chronic disease. No medicine. No periodic physical examination. No measures for emergency.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Living condition: Housework all by himself. Most of the time he has meals in the university canteen, sometimes he cooks. Live in the first floor, house is always humid. Shops for food and living necessity are very close.</td>
</tr>
<tr>
<td></td>
<td>Behavior rules: Sleep for about 7 hours. Get up at 7 am. Normally he does exercises in the morning, plays Chinese chess with friends in the afternoon, watches TV and dances in the evening.</td>
</tr>
<tr>
<td></td>
<td>Relationship with children: Three children, two sons are in other cities, one daughter is another district of this city. Sons both make calls about once a week, the daughter comes to visit him about once two weeks, and helps him do some housework.</td>
</tr>
<tr>
<td></td>
<td>Social life: Friends are living in the same community (university faculty apartment). He always plays chess, dances and exercises with friends.</td>
</tr>
<tr>
<td>Attitude to smart home</td>
<td>He has no smart device.</td>
</tr>
<tr>
<td></td>
<td>He has a positive attitude to smart home.</td>
</tr>
</tbody>
</table>
|                   | In above three modes, he prefers “smart product assist mode”. Because he
thought single product was pointed to figure out one demand and relatively cheap.

What he worries about smart home is that it is hard to learn to use. If there is any problem with software setting or devices themselves, he will have no idea about dealing those problems.

There are three female interviewees and two male interviewees; the average age is about 69 years old. Four of them have the positive attitude to smart home for the elderly. Two interviewees preferred the “smart home assist mode” and two interviewees preferred “terminal, service center and service platform mode”. Their concerns and worries about smart homes are mainly about the difficulty of using, and the accuracy of data.

6.2 Group Two: elderly between 50-60

For group two, I interviewed 10 elderly people who were all 50-60 years old. According to my investigation, all these ten interviewees are currently using smart devices (smart phone, tablet and personal computer) to keep connection with their children and friends through some social applications, for example Wechat. What is more, 7 of them are usually using smart phone as an entertainment tool for watching videos and playing games online. Ultimately, I strategically picked out five representatives for summing up their interview results.

Tables 16-20 present the summary information.

**Table 16. No.6: Mrs. F**

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Age: 53</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: Female</td>
<td></td>
</tr>
<tr>
<td>Education: Junior College</td>
<td></td>
</tr>
<tr>
<td>Occupation: Midwife</td>
<td></td>
</tr>
<tr>
<td>Income per month: 6000 rmb</td>
<td></td>
</tr>
<tr>
<td>She is married, but her husband is working in another city, her only daughter is living in another city as well. Hence, she is living alone for now.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living environment</th>
<th>Behavior rules: She works on weekdays. On weekends, she always dances, plays Mahjong, and travels with friends. Sometimes she goes to visit her husband in another city.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Relationship with children: Her parents have passed away. The only daughter is married and living in a far away city, but they have video chats everyday, sometimes they would travel together.</td>
</tr>
<tr>
<td></td>
<td>Social life: Friends and colleagues are living in the same community. They could chat face to face and through social applications in smart phone. They always organize to dance, play Mahjong, and hang out together.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interaction with smart devices</th>
<th>With the help of her husband and daughter, she has been using smartphone and computer for three years.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>She is now able to skillfully use her smart phone, including app download, phone setting, chatting, shopping, watching video, and checking stocks.</td>
</tr>
<tr>
<td></td>
<td>She is aware of the basic operation of a computer, but as for her, the computer has been totally replaced by her smart phone.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Attitude to smart home</th>
<th>She has heard about smart home from her husband and daughter.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>She has a high positive attitude to smart home system. She is using wireless remote controlled smart sockets in her house brought and set by her husband.</td>
</tr>
<tr>
<td></td>
<td>In above three modes, she prefers “smart product assist mode”. Because she</td>
</tr>
</tbody>
</table>
thought she had not experienced the other two modes, from her experiences, single product is very useful.

What she worries about smart home is that every product has its own control method; it would be a burden to remember different control methods at a time.

Table 17. No.7: Mrs. G

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Age: 56</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: Female</td>
<td></td>
</tr>
<tr>
<td>Education: Middle School</td>
<td></td>
</tr>
<tr>
<td>Occupation: Full-time housewife</td>
<td></td>
</tr>
<tr>
<td>She is living with her husband; her only son is working in another city.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living environment</th>
<th><strong>Behavior rules:</strong> Her husband is still running a business; she is responsible for cooking meals and housework. In leisure time, she chats and hangs out with neighbors.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Relationship with children:</strong> Her parents have passed away. The only son is married and living in a nearby city. They have video chats about once a week; sometimes she goes to visit her son for a few days.</td>
</tr>
<tr>
<td></td>
<td><strong>Social life:</strong> Neighbors are her friends. She always goes shopping, chats and walks with other housewives.</td>
</tr>
</tbody>
</table>

| Interaction with smart devices | With the help of her son, she started to use smart phone half a year ago. |
|-------------------------------| She is now able to use her smart phone to have video chat with her son and watching videos online. |

| Attitude to smart home | She has not heard anything about smart home. |
|------------------------| She has a positive attitude to smart home system, because she thought technical things are amazing and useful. |
|                        | In above three modes, she prefers “terminal, service center and service platform mode”. In her opinion, she would not be patient enough to learn how to control smart home systems, the existing of a third-party service can help her to handle problems. |
|                        | What she worries about smart home is that it would be a burden to learn how to set smart home devices and it would be extra cost to her family. |

Table 18. No.8: Mrs. H

<table>
<thead>
<tr>
<th>Basic information</th>
<th>Age: 51</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender: Female</td>
<td></td>
</tr>
<tr>
<td>Education: Bachelor Degree</td>
<td></td>
</tr>
<tr>
<td>Occupation: Teacher</td>
<td></td>
</tr>
<tr>
<td>Income per month: 7000 rmb</td>
<td></td>
</tr>
<tr>
<td>She is living with her husband. Her parents are living in her hometown; her only daughter is study in the United Kingdom.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Living environment</th>
<th><strong>Behavior rules:</strong> She works on weekdays. On weekends, she always watches TV, goes to a cinema with her husband, and hangs out with friends and colleagues.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>Relationship with families:</strong> She visits her parents about twice a year and talks to them through mobile phone about twice a week. Her only daughter is still study in UK; they would have video chat once a week.</td>
</tr>
<tr>
<td></td>
<td><strong>Social life:</strong> Friends and colleagues are living nearby. They could chat face to face and through social applications in smart phone. They always organize to have lunch or dinner, and hang out together.</td>
</tr>
</tbody>
</table>
### Interaction with smart devices

She learned to use smart phone all by herself since 5 years ago.

She is now able to skillfully use her smart phone, including app download, phone setting, chatting, shopping, watching video, and other social applications. She relies on smart phone in daily life.

She is aware of the basic operation of a computer for the reason that she needs to use it during her work time.

### Attitude to smart home

She has heard about smart home from news and her colleagues.

She has a high positive attitude to smart home system. And she shows interests in purchasing some smart home products for her parents.

In above three modes, she prefers “smart product assist mode”. Because she thought the smart home service was not mature in her city for now, single smart product is more reliable compared with other two modes.

What she worries about smart home is that whether smart home devices are in high quality. It is hard for her to chose adequate product.

### Table 19. No.9: Mr. I

| Basic information | Age: 56  
Gender: Male  
Education: Junior College  
Occupation: Businessman  
Income per month: 100000 rmb in average  
He has been divorced for more than 8 years. His parents have passed away. His only son is working in America. Hence, he is living alone. |
|-------------------|------------------|
| Living environment | Behavior rules: He does not have a fixed work time. In leisure time, he prefers to stay at home and relax.  
Relationship with children: His parents have passed away. The only son is working in America, they have video chats every weekend but hardly meet in recent years.  
Social life: Most of his friends are business partners, they meet and chat frequently because of their business. |
| Interaction with smart devices | He learned to use smart phone and tablet all by himself or many years.  
He is now able to skillfully use his smart phone, including app download, phone setting, chatting, watching video, checking stocks and other social applications.  
He relies on smart phone in daily life.  
He is aware of the basic operation of a computer for the reason that he needs to use it for his business. |
| Attitude to smart home | He has heard about smart home from news but he did not pay attention to it.  
He has a positive attitude to smart home system. He thought it would be very useful for him after he was retired.  
In above three modes, he prefers “comprehensive environmentally intelligence mode”. Because he prefers to have comprehensive automatic functionalities instead of single function.  
He did not show worries about smart home systems. |
<table>
<thead>
<tr>
<th><strong>Table 20. No.10: Mr. J</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basic information</strong></td>
</tr>
<tr>
<td>Age: 55</td>
</tr>
<tr>
<td>Gender: Male</td>
</tr>
<tr>
<td>Education: Doctor degree</td>
</tr>
<tr>
<td>Occupation: Professor of University</td>
</tr>
<tr>
<td>Income per month: 30000 rmb in average</td>
</tr>
<tr>
<td>He is living with his wife; his parents have passed away; their only son is married and working in capital city.</td>
</tr>
<tr>
<td><strong>Living environment</strong></td>
</tr>
<tr>
<td><strong>Behavior rules:</strong> He works on weekdays and travel frequently for his work. On weekends, he always does exercises and reads.</td>
</tr>
<tr>
<td><strong>Relationship with children:</strong> His parents have passed away. He and his wife normally meet with his son about twice a year, but they have video chat frequently for seeing his grandchild.</td>
</tr>
<tr>
<td><strong>Social life:</strong> Friends and colleagues are living in the same community. But in leisure time, he prefers to do exercise and read alone.</td>
</tr>
<tr>
<td><strong>Interaction with smart devices</strong></td>
</tr>
<tr>
<td>He learned to use smart phone and tablet all by himself and he also taught his wife to use them. Besides, he has a smart sport bracelet for recording his sleep condition and exercise.</td>
</tr>
<tr>
<td>He is able to skillfully use his smart phone, sport bracelet, tablet and personal computer. He thought there was no obstacle for learning to new technical devices.</td>
</tr>
<tr>
<td><strong>Attitude to smart home</strong></td>
</tr>
<tr>
<td>He knows some about smart home systems from news reading.</td>
</tr>
<tr>
<td>He has a high positive attitude to smart home system. He is using a smart air detective device for analyzing the air quality in his house and another intelligent air fresher connected with the detective device.</td>
</tr>
<tr>
<td>In above three modes, he prefers “smart product assist mode”. In his opinion, there is no need to arm his house with all kinds of devices; it is better to select adequate products based on true demands.</td>
</tr>
<tr>
<td>He did not show worries about smart home systems and services; and he thought this industry had a big potential to be mature.</td>
</tr>
</tbody>
</table>

There are three female interviewees and two male interviewees above; all of them have the positive attitude to smart home for the elderly. Three interviewees preferred the “smart home assist mode”; one interviewee preferred “terminal, service center and service platform mode”; and the rest one preferred “comprehensive environmentally intelligence mode”. Their concerns and worries about smart homes are mainly about the diversity of control method, cost, and quality of smart home devices.

In the interview process, I was somewhat surprised by the following points observed:

1. Some persons are arranging their own lives, including travel, learning dances and some previously shelved plans.

2. Some of them have begun to make plans for their endowment lives, they would not reject endowment agency, but express a preference for home endowment.

3. Some individuals are increasingly improving the awareness of health care. They both want to keep knowing of their health condition and avoid some chronic diseases and the deterioration by periodic physical examinations.
6.3 Group Three: children of elderly solitaries

In accordance with my investigation, children who need to support elderly parent living alone are usually middle-aged. They are living under pressure and unable to take care of their elder parents. I interviewed five middle-aged people whose father or mother is elderly solitary, and made the following summary by integrating their insights.

1. They are under the pressure from three aspects including family, career and life, so that they deem the concerning for their elderly parents is beyond their grasp. They wish there would be specific housekeeping services to take care of their solitary parents as assistant.

2. Because of their busy work and the geographical distance, they always failed to express their initiative and timely care to their parents, which would definitely result in sorrow and loneliness. They wish their parents could have the resources to develop their own interests and have friends around as companions.

3. Because of different living schedules and attitudes to life, they do not feel comfort to live with parents; all of them are keeping track of their parents over the phone. Therefore, real-time nursing and care become inevitable problems. In fact, they are worried about their parents living alone. If an accident occurs, the missing of best rescue time would trigger tragedy. They wish they could keep up with their parents’ status of health and security (such as receiving the periodic physical examination report).

6.4 Requirements analysis

In the process of sorting the data obtained about needs and expectations from future smart homes, I found that for older people (over 60 years old), their needs and expectations mainly form four aspects: they wish they could live orderly (daily life), could keep aware of their body condition (health care), could be rescued in time once emergency occurs (emergency response), and could have initiative contacts frequently with their children (emotional solace). As for the children generation, they wish they could be informed of their parents’ health condition and the mood in real time. In their perspectives, it is healthier to encourage the elderly to enrich their interest and social life instead of focusing on children only.

After the data reduction, I manually performed the coding procedure by subdividing the data into four categories (i.e., daily life, health care, emergency response, and emotional solace). Table 21 describes these categories with respect to problems identified and proposed requirements for smart home systems design for the elderly solitaries over 60.

<table>
<thead>
<tr>
<th>Categories</th>
<th>Problem description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily Life</td>
<td>Poor sleep, insomnia.</td>
<td>1. Pervasion of health knowledge</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Sleep schedule arrangements and supervision.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. Insomnia recuperation.</td>
</tr>
<tr>
<td></td>
<td>Forgetful, no reminder.</td>
<td>Automatic reminder.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2. Simplification of the new functions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3. In line with the cognition style of the elderly.</td>
</tr>
</tbody>
</table>
## Health care

<table>
<thead>
<tr>
<th>Unhealthy diet (Food random)</th>
<th>Diet proposal based on the health condition</th>
</tr>
</thead>
</table>
| Low frequency of periodic physical examination. | 1. Increase of health consciousness.  
2. Protocol of planned physical examination.  
3. Appointments of physical examination.  
4. Reminder of planned physical examination. |
| Incomprehension of physical examination report | Pervasion of basic medical examination knowledge |

### Emergency response

| No measures for emergency except making calls or waiting for help. | 1. Preparation for emergency situation.  
2. Automatic SOS system.  
3. Fixed connection between the elderly and the closest hospitals. |

### Emotional solace

| Afraid of causing inconvenience to their children, tend to passive communication. | 1. Information transfer to children about the elderly as feedback.  
2. More initiative and scheduled communications from children |
| Only telephone conversation, not face to face. | 1. Specific video connection between the elderly and their children.  
2. Information transfer to the elderly about their children as feedback. |
| Lack of entertainment. Loneliness feeling when they are alone. | 1. Setting up friend cycles in nearby communities.  
2. Organizing activities for the elderly regularly.  
3. Establishing communication between elderly solitaries for searching proper spouse. |
| Cognitive burden of using smart home devices and systems. | 1. Interaction design based on the elderly’ style (considering of the diminution of vision and auditory sense).  
2. Reduction of steps for complete tasks.  
3. Avoidance of extra and useless function.  
5. Third-party administration and service for smart home systems and products. |

From the results of interviews, I figured out that the elderly between 50-60 have different needs and expectations from smart homes and life in general. They had begun trying to communicate via a diversity of media no matter they were living alone or not. Network in rapid growth has penetrated into our lives gradually; the communication modes between them, their children and between them and the outside world are altering. In nowadays, under the guidance of interests or children, the majorities of those people have expressed their great interests in the network, and attempt to interact with smart phones and its related social applications. Besides, some of them have been skillful of using smart devices. Compared with the elderly over 60, the elderly between 50-60 have demands for higher quality lives. They have the ability to operate intelligent products, and squint towards the conjunction of online and offline lifestyles to enrich their own home living area; their initiative and optimistic attitude actively promote the evolution of smart home endowment modes.
7. Discussion

7.1 Requirements conclusion

The research question in this research is “what physical and psychological needs of solitary elderly people in China should be addressed by an interactive smart home system?” For older people (over 60 years old), their needs and expectations mainly form four aspects: they wish they could live orderly (daily life), could keep aware of their body condition (health care), could be rescued in time once emergency occurs (emergency response), and could have initiative contacts frequently with their children (emotional solace). Compared with them, the elderly between 50-60 have demanding for higher quality lives. They have the ability to operate intelligent products, and squint towards the conjunction of online and offline lifestyles to enrich their life. As for the children generation, they wish their parents could have the resources to develop their own interests and have friends around as companions.

7.2 Implications for design practice

In Maslow’ hierarchy of needs pyramid, once physiological needs are met, the attention of people will turn to safety and security. Hence, for the design practice, the safety needs are most significant and essential. The relevant aspects about safety needs in my thesis are daily life, health care, and emergency response. Meanwhile, it should be much better to involving children roles to satisfy their higher loving and belonging needs. In addition, at the top of the pyramid, self-actualization is the highest demand and highest goal of home endowment. By enriching their hobbies and interests, designer can rely on the systems to mobilize their enthusiasm and rebuild confidence. It means the elderly can fully experience life and enjoy life.

Based upon the above analysis of the typical problem home endowment on conjunction of requirements from three generations, I put forward design proposal focusing on comparison between literatures and my findings.

We can make a conclusion based on the literature review in Chapter 4 that normally the functionalities of protection for health and safety are with the highest priority in the process of designing a smart home system for the elderly living alone because they have the higher request for independency and security. Due to the degradation of bodily functions, sweeping, cooking and others seemingly simple housework may be burdens in this particularity endowment mode. Meanwhile, due to the deterioration of memory, they are prone to be forgetful about turning off hydropower switches, resulting in consequential accidents. What is more, once unexpected accidents happen, triggered by some chronic diseases or sudden illness, there is the serious problem of timely interventions and rescue. In considering the design process, security monitoring is in the highest priority, supporting with assistant for they daily life by means of setting up the third-party platforms to guarantee the independence of life.

In fact, the elderly living alone has obvious health-conscious, they want to know their health status, but also hope to have targeted daily diet to prevent diseases. However, under the influence of the traditional medical concept, in reality, they are still not active in periodic physical examinations before they get illness, or they will have simple
examinations in a passive situation such as community examinations for free rather than regular and comprehensive check. This lead to a delay of best treatment time for some diseases those are not prone to detect. Meanwhile, because of the inert and unsupervised environment, elderly solitaries may have irregular diet and unusual living habits, it will not only have impact on their health, but also cause extra concerns in children. Some elderly individuals are still concerned about their health and do regular examination, but suffer from incomprehension of professional report. In previous designs listed in Chapter 4, there are third-party services for monitoring abnormal vital signs of body as the link between the elderly and medical institutions. Actually, more services can be served for them. On one hand, drawing up personalized periodic physical checkup plan, offering services for reservation and report interpretation. On the other hand, providing recommendations and suggestions for reasonable diet and daily schedule based on the physical condition diversity. Not only that, the medical files can be timely feedback to children generation for promote the elderly’s positivity.

Through my interviews, I discovered that concerns and comforts from children play particularly vital roles in psychological health of the elderly. But communications between them are generally initiative done by the children generation; the elderly are in a passive position. In previous designs listed in Chapter 4, there is no functionality, which is targeted for solving this psychological problem. It is can be considered that by utilizing smart home products or smart home services to encourage children generation to be more active in obtaining information about their parents, and then convey their concerns and care through diversified ways, such as voice, video and other interactive means for making up the affection.

Surveys by me show that elderly people living alone have the hope of enriching their later lives. The downside is that the pace of modern science and technology development is far beyond their ability to catch up with owing to cognitive aging and the lack of interaction with electronic information technology equipment. That fastens the obstacles and burdens for external communication. For the entire smart home system design, in addition to perfect functions, interaction design should also be taken into account seriously based on the interaction habits of the elderly. In next decade, the design of smart home systems for the elderly will be in a tendency of combining social media platforms to narrow down the gap between them and the times for better life.

7.3 Implications for research

Although the emergence of smart homes has been existed for decades, Aldrich (2003) asserts that “smart home is still a typical case of technology push rather than consumer pull” (as cited in Berg, 1994, p.176); what can be realized by current domestic technologies weights more than what are expected by consumers. At least for now, insufficient attention from designers is paid to the usability evaluation, and they are eager to present their revolution in domestic technologies and services rather than figure out the real demand of consumers. So in my research, I used the field interview method to dig their real needs. As can be seen, from the aspects of interviewees, there are no uniform design and control standards for smart home products, a variety control methods should be mastered if using several different products at the same time.

Besides, the real adoption of smart homes in reality is different with the assumptions. According to Aldrich (2003), there are some obstacles to consumer take-up of smart homes that includes the dependence of old housing stock, lack of a common protocol, high initial investment from the consumer, little usability evaluation by suppliers, and “technology push” by suppliers. These obstacles are kind of smart home adoption
feasibility indexes. In fact, China is in the development from a low-income country to a middle-income country. Therefore, based on the fundamental realities of China, it is difficult to have a great degree of upgrading of the average level of smart home in the short term.

7.4 Limitations

This thesis has two inevitable limitations.

1. The literature review on existing smart home systems for the elderly is not systematic. It is possible that there are other existing smart home designs, which are not included into my review classification.

2. All interviews were conducted in a fixed location of Xiamen city. The randomly chosen interviewees all have higher education background and income than the average level in China. As a consequence, the acceptance of smart home will be inevitable higher than the acceptance in entire China.
8. Conclusion

This thesis aims to explore the real demands of older people living alone in China based on existing smart home design with the purpose of combining physical needs and psychological needs. Most of existing smart home designs focus on performing different functions packaged into friendly user interfaces, but emotional perspectives are scantily taken into account or are ignored. Hence the research question is “what physical and psychological needs of solitary elderly people in China should be addressed by an interactive smart home system?” In order to solve this problem, the research process has been through four main stages, which are analysis of background in China, analysis of existing smart home modes for the elderly, conducting interviews for requirements collection and comprehensive requirement analysis.

For the purpose of digging comprehensive and potential requests, interviewees are divided into three groups including the elderly over 60, the elderly between 50-60, and the children of elderly solitaries. After the analysis of interview results, I found that for older people over 60, their needs and expectations mainly from four aspects. They wish they could live orderly, could keep aware of their body condition, could be rescued in time once emergency occurs, and could have initiative contacts frequently with their children. The majorities of elderly between 50-60 have expressed their great interests in smart phones and social applications. Compared with the elderly over 60, the elderly between 50-60 have demanding for higher quality lives. They have the ability to operate intelligent products. As for the children generation, they wish they could be informed of their parents’ health condition and the mood in real time. In their perspectives, it is healthier to encourage the elderly to enrich their interest and social life instead of focusing on children only.

In brief summary, the further smart home design can be started in three aspects.

1. Setting up the third-party platforms and smart home systems as assistants to the children generation for helping the elderly living with independency and security.

2. Building the link between the elderly and their children. Using the method of reminding to encourage the children to take initiative care for the elderly.

3. In full consideration of the elderly cognition and interaction patterns, smart home systems can utilize diversity scientific and technological means to enrich their old age lives.

This thesis makes contribution to the design of smart home systems for the elderly by providing comprehensive requirements. The characteristic of this research is that I did survey in target group as well as those who would be the next elderly generation. It provides a direction for the development of smart home for the elderly. I hope this research can set the stage for future smart home system building, and promote the evolution of smart home industry.
References


Appendix A. Plan of interview

For all groups
- Age
- Education
- IT usage patterns: smart phones, Internet
- Income
- Relationships with children (1,2)/parents (3)
- Perception about smart home devices
  1. Have they heard about smart home?
  2. From where do they have knowledge about smart home (news readings, TV, friends and family)?
  3. What do they know about current smart home?
  4. Do they have experience of smart home? Give examples of smart home devices with pictures, from different areas: security, healthcare, comfort. Give examples of pictures with a model of integrating different devices in a smart home. Give comparison between three basic smart home modes for elderly.
    If yes, how they started to use SH devices (family, healthcare, own initiative), what are their thoughts and attitudes about smart home (satisfaction, dissatisfaction, concerns, demands, expectations)?
    If not, do they willing to use smart home? Which mode they prefer? What are their thoughts and attitudes about smart home (satisfaction, dissatisfaction, concerns, demands, expectations)?

Specific for group 1
- Health condition
- Living environment
- Behavior rules and social life
- Expectation and demand for living independently

Specific for group 2
- Behavior rules and social life
- Expectation and demand for living independently

Specific for group 3
- Obstacles in interacting with parents
- Expectations for smart home
Appendix B. Interview questions for group 1

**Background data:** Age, Gender, Education, Income.

**Q:** Do you live alone?

**Q:** How old are you? (Record gender at the same time)

**Q:** What is your educational background? (Bachelor, high school, middle school, primary school) What was your profession before your retirement?

**Q:** What is your mainly and average monthly income? (Retirement pension? Support from Children? Or others, for example, are you still running a business?)

**Present condition:** Health condition, Living environment, Behavior rules.

**Q:** What is your health condition? Do you always need to visit a doctor? (Once a week? Once a month? Or when you needed?)

Do you have any disease? (If had, does it have influent on your life? how?)

Do you have any chronic disease? (High blood pressure? Does it have influent on your life? How?)

Do you need to take pills? How often? (Once a day? Three times a day?)

Do you have problem with your sense organ? (Diminution of vision? loss of hearing?)

Do you have problem with daily movement? (Do you have any pain or hurt in your arms and legs? Will it influence your daily activities?)

Do you have any problem with your memory? (For example, do you often forget to do something, like taking pills.)

Do you have any problem with your sleep condition? (Do you sleep well at night? Why? How long do you sleep at night?)

**Q:** How is your living environment?

Do you need to climb stairs? (Does it hard for you?)

Do you need help for house clean? (If needed, who help you to do the cleaning? How often? If not, how often do you clean your house?)

How do you do the laundry? (By yourself?) How often?

Do you think is there any inconvenient problem in your living environment? (For example, in south China, the ground of lower floors will become wet before it rains. For example, it is hard to have shower in winter?)

Do you need help for purchase of living necessities? (Especially food) If not, do you live near a shop? Does it convenient for you to do purchase?

Do you live in an environment in which you can easily find a friend for companion?

Do you live in an environment where the community offers health care? (free blood pressure examination?)

Do you have any measure for emergency in your home?
Q: When do you get up in the morning?
Do you cook by yourself? (If not, who cook for you, or do you buy your meals from outside)
How many meals do you have for a day? (Normal 3 meals a day, if not, why?)
What do you often do? (Except sleeping, eating, like watching TV, hang out for a walk, meeting with friend?)

Social life: Relationship with children, Relationship with friends, Social habit.

Q: Do you have children? Do you live near your children?
How is your relationship with your children? Do they visit you often? (Once a week? Or on festivals?) What do you do when meeting with them?
Do you talk to them often? How connect? How often? (Once a week? Or it depends?)
Do you have any obstacles in interacting with your children? (They are too busy to talk or visit?)

Q: Do you live near your friends? Or do you make friends with your neighbors?
How is the relationship with your friend? Do you meet often?
How is the relationship with your neighbors?

Q: Do you have any habits for daily life? (Dance, work out, play chess?)

Smart home topics: IT usage pattern, Smart home.

Q: Do you have a smart phone or other smart device? (Pad, computer, watch?)
Q: Do you have any knowledge about smart home?
If not, introduce to them by some direct pictures about three types of smart home. Then ask:
Do you feel interested in smart home? (Why or why not)
Which type does you interested in? (Why or Why not?)
Do you have any special need and expectations based on smart homes? (Comfort, health, safety, social, physiological?)
Do you have any concern about smart home? (Expensive? data security? difficulty of use?)

Q: Do you have any knowledge about smart home?
What do you know about current smart home? (From their aspects, what functions a smart home have?)
Do you have any experience?
If yes, how do you start to use smart home? (Family? healthcare? own initiative?)
What kind of smart home are you using? (Single device? smart home system? for health care? for safety? for comfort?)
Satisfaction and dissatisfaction? (Why?) Advantages and disadvantages? (Why?)
Then show them the three types of smart homes and introduce.
Do you feel interested in smart home? (Why or why not)
Which type do you prefer? (Why?)
Do you have any concern about smart home?
Do you have any special needs and expectations based on current smart homes?

About introducing the three types:
Take pictures as examples.
Give relative detailed explanation about all types.
Make comparison between these three types.

**Expectations and demands for life**

Q: Do you feel satisfied with your daily (social) life? (Why and Why not?)
Do you need a guide for daily life? (Remind of sleep, remind of taking pills? Advices of food?)
Do you need to be offered services when necessary? (When emergency happens)
Do you have other expectation in physical level?
Q: Do you feel lonely frequently? (Why or Why not?)
What are you expecting from children?
What are you expecting from your friends?
What are you expecting for entertainment?
Do you have other expectation in mental level?