Design of Intelligent Medicine Box for Elderly People Based on Context Awareness and FAST Theory

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Abstract. Based on context awareness and FAST (Function Analysis System Technique) theory, this paper explored the needs of elderly users and designed an intelligent medicine box for them to provide more comprehensive health services. It defined context through context analysis method, combined four context factors to obtain human-machine interaction model, and built a functional tree through the FAST theory to analyze product design factors and functional transformation forms. Finally, this paper established a product shape matrix upon functional combination and human-machine relationship, and selected the best design scheme. Through a practical application to a case, the validity of context awareness and FAST theory hybrid approach and their technical feasibility and effectiveness was demonstrated, and an accurate mapping relationship between objective product performance and user needs was formed.

1. Introduction
China has entered aging society at the end of the 20th century, and by 2050 it will become a deeply aging country. According to the National Family Development Report 2015 issued by the National Health and Family Planning Commission, nearly 58.1% of the elderly have been diagnosed with chronic diseases and need to take medicine for a long time. In the case of accelerated aging and high incidence of chronic diseases, it is necessary to design better intelligent medicine box for the elderly[1]. Therefore, this paper obtained the needs of elderly people through immersive context awareness, and transformed user needs and integrated product functions by FAST theory.

2. Context awareness and FAST Theory

2.1. Context awareness
Context awareness was proposed by Schilit and Theimer in 1994. At present, the study of context awareness mainly includes two aspects, one is to study how people perceive, understand and feedback contexts, and the other is to build a context-aware system for users[2]. Hugh Beyer once pointed out that context awareness can collect users' behaviors, situations, and speeches, which can help designers obtain enough data information, and avoid personal subjective speculation[3]. Schilit et al. divided the situation into computing context, user context and physical context, and Chen and Kotz added time context to this[4]. Overall, the integrated context factor analysis assists design decisions and establishes a direct mapping between user requirements and product design requirements to ensure a high degree of consistency between them.
2.2. FAST theory

FAST theory was proposed by Bassevi in 1965. The theory follows a top-down analysis sequence, uses function trees to define and analyze product functions, and focuses on the important functions to increase product value[5]. Designers can use the function tree and the "How-Why" question and answer method to find the root node along the critical path, and determine the relationship between basic functions and sub-functions[6](Fig1).

![Fig1.FAST functional system model](image)

![Fig2. The application process of context awareness and FAST theory](image)

2.3. Integration of context awareness and FAST theory

Context awareness uses the context information of “human-machine-environment” to complete the classification of user cognition, behavior and experience, explore the invisible needs of users' subconscious, increase the pertinence and personalization of functional mapping, and solve the problem of “what to do”. FAST theory can translate user requirements into design requirements, determine product core functions, develop extension functions, find reasonable functional implementation patterns, and solve the problem of "how to do". By combining context awareness with FAST theory, designers can complement each other's strengths, accurately capture user pain points, and make product function design clear(Fig2).

3. Analysis of the needs of the elderly based on context awareness

3.1. Context definition

A context includes all information about an entity's characteristics. Any information that interacts with the entity is a context[7]. Context factors include user context, social context, physical context, and temporal context. Traditional methods of analysis are difficult to adapt to the dynamics of user needs. Using context analysis to define contexts, designers can effectively organize and describe useful information to accommodate fuzzy user needs[8]. The context definition is shown in Table 1.

| Level 1 context | Level 2 context |
|-----------------|-----------------|
| User            | Target group: elderly people. Age: 60-74 years old. Characteristics: patients with chronic diseases, living alone, paying attention to physical health. |
| Product         | Appearance: round and friendly. Color: mainly solid color. Function: modular classification. Structure: detachable. |
| Environment     | Indoor or short outdoor activities. |
| Behaviour       | Power on and off, interface interaction, scanning, APP interaction. |

3.2. Context factor analysis

3.2.1. User context. The elderly aged 60-74 are called young seniors. In terms of health, they often suffer from chronic diseases such as hypertension, diabetes, and coronary heart disease, and have the
characteristics of multiple diseases[1]. There are 6 common mistakes in elderly people during medication: don’t take the medicine on time, taking the wrong dose, taking the metamorphic medicine, privately dispensing the medicine, don’t pay attention to the medication precautions and don’t supplement the lack of medicine.

3.2.2. Social context. At present, home-based care is still the choice of most elderly people in China. The weakening of family pension function makes the elderly have to improve their initiative in health care. The “Smart Pension” model introduces the Internet of Things and cloud technology into the elderly medical products, creating a variety of interactive modes[10].

3.2.3. Physical context. Through the analysis of the existing intelligent medicine boxes for the elderly, it is concluded that the main ways of interaction between users and products are voice interaction, visual interaction and behavioural interaction, which are realized through three ways: “human-machine”, “machine-human” and “human-machine-human” (Fig3).

3.3. Elderly needs analysis
Summarize the needs of elderly people based on context awareness, as shown in Figure 4.

4. Design scheme of the intelligent medicine box for elderly people

4.1. Functional structure construction
According to the function, the basic functional modules of the intelligent medicine box are divided into three categories: storage, prompt, and information service. Through the function tree, designers can explore the relationship between functions and make functions integrated (Fig5).
4.2. Morphological matrix construction
As shown in Table 2, the morphological matrix is established to further explore the functional implementation form and generate more technical solutions. For one of the functions, different technical processes can be selected to meet the design requirements, so it is necessary to select the best among several feasible solutions[5].

Table 2. The morphological matrix of elderly intelligent medicine box

| Sub-function     | Plan 1                | Plan 2                | Plan 3                |
|------------------|-----------------------|-----------------------|-----------------------|
| A. Storage function | Drawer layering      | Block partition       | Monomer separation    |
| B. Prompt function | Light                | Buzzer                | Speaker               |
| C. Information import | Scanner             | External keyboard    | Touchscreen           |
| D. Information export | Bluetooth           | USB                   | Associated APP        |
| E. Opening method   | Twisted              | Buckled               | Sliding               |

According to the original understanding of the possible sub-functions in elderly intelligent medicine box listed in Table 2, there are 243 theoretically effective programs. By comparing various theoretical schemes, considering user characteristics, operability, production cost, use environment, and convenient maintenance, the design scheme of elderly intelligent medicine box is finally determined to be the combination of A2, A3, B1, B3, C1, C3, D3, E3.

5. Design verification

5.1. Appearance design
The design scheme is shown in Figure 6 and Figure 7. The main color of the product is white and gray, giving the elderly a relaxed and casual visual sense. In order to adapt to the vision of the elderly, only the "Power" and "OK" operating buttons are set. And the seven independent medicine bottles in the product configuration use high-purity color to enhance the discrimination.

Fig6. Elderly intelligent medicine box rendering  Fig7. Monomer medicine bottle rendering

5.2. Material selection
In the material selection, the medicine box shell is made of medical PVC, which has low production cost, wide application, easy processing, excellent chemical resistance, mechanical properties and electrical properties. The handle and the sliding door surface are frosted to provide a non-slip and a better grip. The external medicine bottles are made of translucent PVC for easy access to medicines.

5.3. Functional analysis
This product consists of two parts. One part is the main medicine box, with storage area, scanner, touch screen and speaker. The other part is seven external medicine bottles with bases for the charging ports. The medicine bottle is divided into three parts. The top is a loop for easy carrying. The middle part is an LED light. The lower part is a storage space, and the internal separation structure can be modularized according to the number of times the elderly take the medicine. The functional analysis of the product is shown in Table 3.
Table 3. Elderly intelligent medicine box function analysis

| Functional area          | Function          | Characteristic                                      |
|--------------------------|-------------------|----------------------------------------------------|
| Monomer medicine bottle  | Dispense medicine | Packed by week, Easy to carry                      |
| Touch screen             | Switch function,  | Tilted screen for easy operation, Indicative and   |
|                          | Display information| concise icons                                      |
| Scanner                  | Scan barcode      | View the details of the medicine by scanning the   |
|                          |                   | code.                                              |
| Speaker                  | Voice announcement| Alarm clock prompt, Synchronized voice prompt      |

6. Conclusion

Based on context awareness and FAST theory, this paper conducted research on elderly intelligent medicine box, explored the needs of elderly people through context factors, and discussed the interaction mode between users and products. Through design verification, the combination of context awareness and FAST theory can realize the effective transformation from the demand layer to the behaviour layer, making the product more suitable for the needs of elderly people. This method is feasible in the development of similar products and is expected to provide research ideas for related designs. Subsequent researches can continue with user demand dynamics and context-aware interaction design.

Acknowledgments

This research is supported by Research Project of Double Support Program for Art Special Project in Sichuan Agricultural University, 2018 and Opening Foundation for Industrial Design Industry Research Center, Key Research Base of Humanities and Social Sciences, Sichuan Education Department (GYSJ18-037).

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