Research on Smart Home Product Design Strategy Based on TRIZ Conflict Resolution Principle

Yanqing Chen[1, *], Ling Pang[2]
*546453250@qq.com, 2474894403@qq.com

[1]School of Design and Art Xiamen University of Technology Fujian, China

[2]School of Design Guangxi Normal University Guangxi, China

Abstract— In order to quickly find the innovative direction of smart home products and improve the design efficiency, a design method for smart home products based on the TRIZ conflict resolution principle is proposed. Based on the design principles of smart home products, the engineering parameters, invention principles, and conflict matrix of TRIZ are professionally reconstructed. Combined with the solution steps of the TRIZ conflict resolution principle, a method and process suitable for smart home product design are established in a targeted manner, including analyzing design problems, solving design analysis and forming design plans. Through the design case of the household sterilizer, it is proved that the smart home product design method based on the TRIZ conflict resolution principle has certain operability, which can provide directions and ideas for the innovative design of smart products in a targeted manner, effectively solve the conflict problems in the design, and are conducive to improving the designer's efficiency.

Keywords-TIRZ; Conflict resolution; Smart home; Design methodology

1 INTRODUCTION

Thanks to the development of artificial intelligence, big data and other technologies, the scale of the global smart home market has continued to grow in recent years. The trend of intelligent development deepens the complexity and systematicness of home appliance experience, and common traditional design innovation methods, Common design methods for product design, including brainstorming, trial and error, reverse thinking and so on, have been unable to meet the design requirements of smart home products involving multiple fields and disciplines [1]. TRIZ is an innovative design method established for engineering and technical problems. After continuous supplementation and improvement by innovative technology researchers and practical users, the original 39 engineering parameters were increased to 48 [2], expanding the range of problems that can be solved. Scholars at home and abroad introduce the use of TRIZ theory in the field of engineering design field to point out the way of product technological innovation. This theory has achieved fruitful results in solving technical conflict and structure optimization [3], especially in the application of the TRIZ method in the specific subject, multi-method integration and design theory to construct the model, and prove its validity in solving the problem of innovation. Therefore, in order to improve the innovation design

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efficiency and quality of smart home products, according to the design principles of the development of smart home products, based on the 2003 new version of the conflict matrix, re-summarizing the engineering parameters and invention principles, and based on TRIZ theory, a method suitable for the design of smart home products is proposed. Finally, this paper took the feasibility of household disinfection machines as an example. This method can effectively improve the design quality and efficiency, and has certain practical significance and practical value.

2 MATERIALS AND METHODS

2.1 Design Principles of Smart Home Product

China's smart home industry started in the early 1990s, and experienced the budding stage of product recognition, the pioneering period of independent research and development, the wandering period of vicious competition and the evolution period of product integration. Entering the current stage of rapid advancement, we have ushered in a period of diversified development, such as data-driven and artificial intelligence 4. In the process of suing smart home, there are many control elements, and the distribution of control objects is relatively scattered. Reasonable design of attributes, such as the size, color, and position distribution of control elements can reduce the trial and error rate. A sense of security is the most basic need in people's lives. Despite the continuous development and improvement of the Internet and big data technologies, there are certain security risks and interaction burdens in home products and smart home environments, and a more natural interaction method needs to be adopted. There are many brands and control systems of smart home products, and users The age span is large. And according to the actual situation in China and related literature [5], it is necessary to take into account the usage habits of users of different age groups, the design principles of smart home products are divided into compatibility, security, usability, and universality, which are represented by C, S, U and N respectively. See Table 1 (source: all pictures and tables in this article are drawn by the author).

Table 1 Smart home product design principles

SMART HOME PRODUCT DESIGN PRINCIPLES	**Elements and Codes**			
	Design Principles	***Demand characteristics***	***Product properties***	***Code***
1	Compatibility	The appearance of the product is adapted to the user's psychology	Product shape, color, material, etc.	C
2	Security	Prevent information leakage, safe and reliable	Product shape, color, material, etc.	S
3	Usability	Complete functions and simple operation	Easy to maintain and operate	U
4	Universality	Product and brand compatibility, taking into account the user span	Compatibility, adaptability, etc.	N

2.2 Construction of Smart Home Product Design Method

2.2.1 Matching of Smart Home Product Design Principles and TRIZ Engineering Parameters

TRIZ standard engineering parameters are derived from the analysis and refinement of a large number of patents. They not only have certain universality for engineering problems, but also provide effective guidance for solving product man-machine problems, product structure optimization and material saving in the field of product design [6-7]. When using TRIZ standard engineering parameters to solve certain design problems, some engineering parameters are used with high frequency and correlation. In order to achieve the conversion rate of product engineering parameters, 48 engineering parameters are summarized based on 4 principles of smart home product design. In this way, on the basis of the professional reconstruction of 48 engineering parameters, it is reduced to 24 exclusive engineering parameters related to the design of smart home products, and a correlation table between TRIZ standard engineering parameters and the design of smart home products is constructed. Realize the transformation of smart home product problems into technical conflicts, thereby improving design efficiency, see Table 2.

Table 2 Smart home product design and engineering parameters correlation table

ENGINEERING PARAMETERS	***Engineering parameters and codes***			
	Engineering parameters	***Code***	***Engineering parameters***	***Code***
1	Length of stationary product	C	Noise	C
2	Length of moving product	C	Adaptability	N
3	Area of stationary product	C	Compatibility	N
4	Area of moving product	C	Product operability	U
5	Volume of stationary product	C	Reliability	S
6	Volume of moving product	C	Ease of Maintenance	N
7	Shape of product	C	Safety	S
8	Velocity of product	S	Aesthetics	C
9	Product structure stability	S	External Harmful Factors	S
10	Product temperature	C	Product Manufacturability	U

ENGINEERING PARAMETERS	*Engineering parameters and codes*			
	Engineering parameters	***Code***	***Engineering parameters***	***Code***
11	Product illuminance	C	Degree of Automation	U
12	loss of information	S	Complexity of Control	U

2.2.2 Establish a Frequency Table of Smart Home Product Design Principles and Invention Principles

According to the above-mentioned smart home product design principles, 24 engineering parameters are selected to draw the corresponding frequency diagram of the invention principle, as shown in Figure 1. This paper assumes that the frequency of the design principles conforms to the normal distribution, and then draws a normal distribution diagram of the frequency of the invention principles of the smart home product design principles, see Figure 2, and is composed of the samples were fitted with a normal distribution function curve. According to the normal distribution and the sigma principle, the ratio of numerical distribution in (μ-σ, μ+σ) is 0.6826, that is, the proportion of data located at (-∞, μ-σ] [μ+σ, +∞) is 31.74%. The purpose of this paper is to remove the outliers below the mean, that is, to remove the data with a proportion of 15.87% in (-∞, μ-σ], which are the principle of the invention with serial numbers 8, 11, 20, 21, 22, 23, 27, 33, 34, 36, 38, according to which 29 invention principles that are highly related to the design principles of smart home products can be extracted.

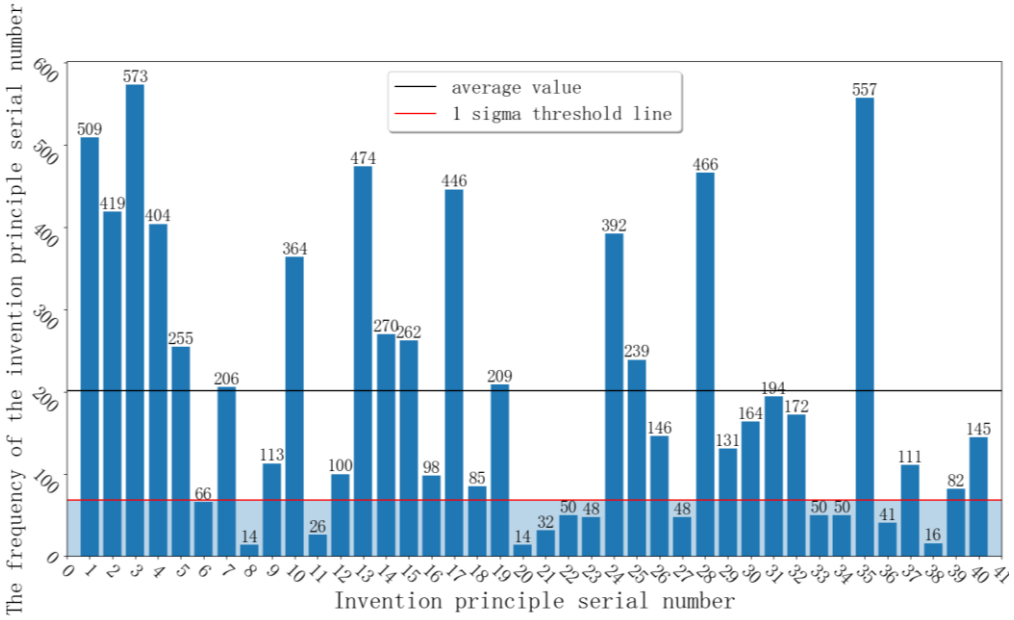

Figure 1. Frequency diagram of invention principle.

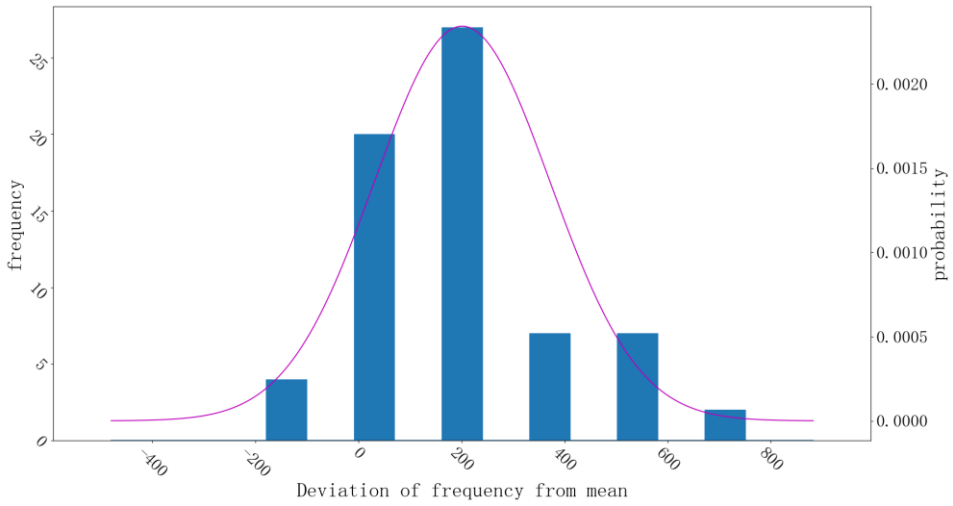

Figure 2. Invention principles frequency normal distribution map.

2.2.3 Reconstruction of New Invention Principles of Smart Home Product Design

In order to improve the design efficiency of smart home products, the 29 invention principles selected above are renumbered, sorted, merged, named, explained, and given examples, as shown in Table 3. For example, the original article 5 merging Principle and the original article 6 universality principle involve the integration of different functions, so they are merged and renamed as "merging". The original article 14 of the principle of spheroid-curvature and the original article 15 dynamics principle involve changing the relative motion state of the product or its components, so they were merged and renamed as "dynamics principle". The original article 26 the principle of copying and the original article 28 the principle of mechanics substitution involve the replacement of the original product or other fields to replace the mechanical field, so they are merged and renamed as "substitution principle". The original article 29 pneumatic and hydraulics principle and the original article 37 thermal expansion principle involve the use of pneumatic and liquid to generate expansion characteristics or buffering effects, so they are merged and renamed as "gas or liquid properties". The original article 30 the principle of flexible shells or thin films, the original article 31 the principle of porous materials, and the original article 32 the principle of color changes involves changes in parameters such as materials, colors, and temperatures. Therefore, the original articles 30 and 31, 32 are merged with the original 35 parameter changes principle. After obtaining 24 exclusive engineering parameters and 22 new invention principles applicable to smart home product design, a brief table of conflict matrix for smart home product design is established, as shown in Table 4.

Table 3 The new invention of smart home product design

new invention of smart home product design	**name and explanation**	
	name	***explanation***
H1	Segmentation	Divide the product into independent parts according to the function of the product or improve the degree of independence of the product components
H2	Taking out or substract	Extract harmful functions and attributes or extract necessary functions and attributes of products
H3	Local quality	Extract the necessary features or attributes of the product
H4	Asymmetry	Use asymmetric products instead of symmetry, increase the degree of product asymmetry
H5	Merging	Combining different functions into one product
H6	Nested doll	A complete (or partial) product is embedded in another identical complete (or partial) product
H7	Preliminary anti-action	Pre-complete partial or whole reaction
H8	Preliminary action	Pre-complete some or all of a function or action，pre-position the product in a convenient location
H9	Equipotentiality	Change the lift of the product
H10	The other way roud	Use the opposite action to achieve the same purpose
H11	Dynamic	Adjust the parts of the product, move the stationary product, or move the parts of the product relatively
		Use curves, surfaces, and spheres instead of lines, planes, and cubes
H12	Partial or excessive action	If the product cannot meet the required requirements, use a little less or a little more according to the actual
H13	Another dimension	Utilize 2D, 3Dspace or the reverse side of the product
H14	Periodic action	Transform a continuous state into periodic motion or change its frequency
H15	Periodic action	Transform a continuous state into periodic motion or change its frequency
H16	Intermediary	Use a mediator to pass or complete a desired action
H17	Self-service	The product has the functions of self-replenishment and self-recovery, or its materials can be reused or recycled
H18	Substitution	Replica replaces original product
		New systems such as electric and magnetic fields replace mechanical systems
H19	gas or liquid properties	Utilize gas, liquid to produce swelling properties or buffering effect
H20	State and parameter changes	Flexible housing or film instead of general structure
		Make the product porous or use the porous to

new invention of smart home product design	name and explanation	
	name	***explanation***
		change the original characteristics
		Change properties such as color, state, texture, temperature, density, flexibility and flexibility
H21	Inert atmosphere	Inert environment or vacuum environment instead of ordinary environment
H22	Composite materials	Single material replaced by composite material

Table 4 Conflict matrix brief table

Conflict matrix	***Parameters to prevent deterioration***				
parameters to improved	Length of moving product	...	Loss of information	…	Complexity of Control
Length of moving product	H13, H1, H3, H20, H11, H4	…	H1, H16, H17, H2, H3, H20	…	H20, H1, H3, H18, H17, H10, H5, H2
...	...	...	...	…	...
loss of information	H18, H17, H8, H19, H1, H12	…	H16, H8, H6, H17, H3, H18, H2, H20	…	H8, H5, H17, H2, H3, H14
...	...	...	...	…	...
Complexity of Control	H20, H13, H11, H8, H4, H18, H9, H1	…	H17, H8, H6, H3, H4, H18, H16, H1, H20	…	H8, H17, H19, H3, H1, H2, H18, H6

3 RESULTS AND DISCUSSION

3.1 Smart Home Product Design Method Based on TRIZ

The design process of smart home products based on TRIZ mainly includes three steps: analyzing design problems, solving design problems and evaluating design schemes. Compared with common design methods, it is more practical and systematic. The specific process is shown in Figure 3. In the stage of analyzing and designing problems, it is necessary to clarify the design requirements of users, and then use the 24 engineering parameters of smart home products to describe the design requirements, and clarify the parameters to be improved and the parameters to be prevented from deteriorating, which is transformed into a TRIZ problem [8-10]. In the stage of solving the design problem, according to the parameters to be improved and the parameters to be prevented from being deteriorated, look up the smart

home product design conflict matrix table (Table 4), determine the corresponding invention principle, and draw a sketch. In evaluating the design scheme, the feasibility assessment of the design scheme formed by the recommended invention principle is carried out according to the actual situation. If it cannot meet the needs of the analysis and design problem stage, it is necessary to return to the TRIZ problem transformation stage to re-determine the design conflict until the scheme evaluation is passed.

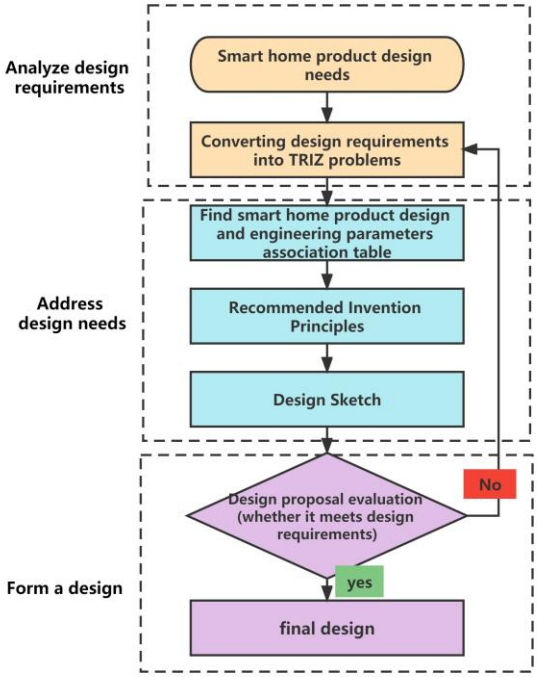

Figure 3. Smart home product design flow chart.

3.2 Application Examples

3.2.1 Analysis of Design Problems of Household Disinfection Machine

Under the adverse impact of the new crown epidemic, the use of disinfection products has surged. According to the TRIZ based smart home product design method proposed in this paper, the design is improved for the capacity, safety, and ease of operation of the household sterilizer.

When translating into a TIRZ problem, identify parameters to improve and parameters to prevent from deteriorating. The capacity of the machine will increase", but "the floor space of the household disinfection machine will increase". According to Table 4, the recommended principles of the invention with serial numbers H11, H3, H6, H4, H20, H10, H18, H13 can be obtained.

If "the omission of information of the household sterilizer is reduced", then "the working state of the household sterilizer can be observed in time", but "the illumination of the structure of the household sterilizer will increase". According to Table 4, the recommended principles of the invention with serial numbers H14, H20, H16, H18, H3, H5 can be obtained.

If "the operability of the household sterilizer is increased", then "the usage of the household sterilizer will be simple", but "the stability of the structure of the household sterilizer will be reduced". According to Table 4, the recommended principles of the invention with serial numbers H17, H1, H20, H16, H22, H15, H3 can be obtained.

3.2.2 Solution to the Design Demands of Household Sterilizers

According to the actual situation, applying the H13 multi-dimensional principle, the interior of the household sterilizer is designed as a multi-layer structure, and different partitions are set according to the size, shape and type of the sterilized items, as shown in Figure 4.

According to the actual situation, the principle of parameter change of the H20 state is applied, and the shell of the disinfection area of the household sterilizer is made of translucent material, so as to observe the internal working state in time, as shown in figure 5.

According to the actual situation, the H1 segmentation principle is applied, and the household sterilizer is divided into a display area, a disinfection area and an indication area for users to operate and use, as shown in Figure 6.

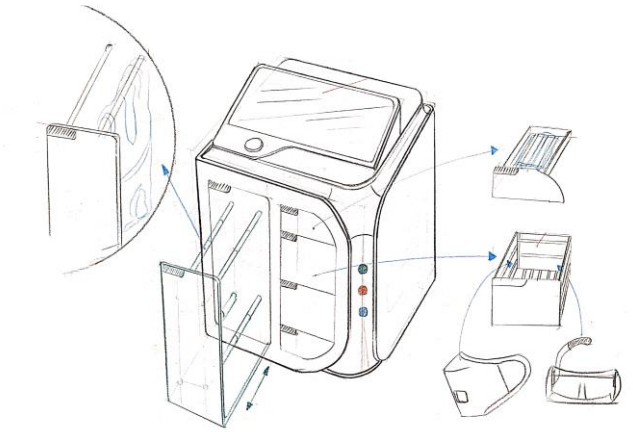

Figure 4. Sketch

Figure 5. Shell material.

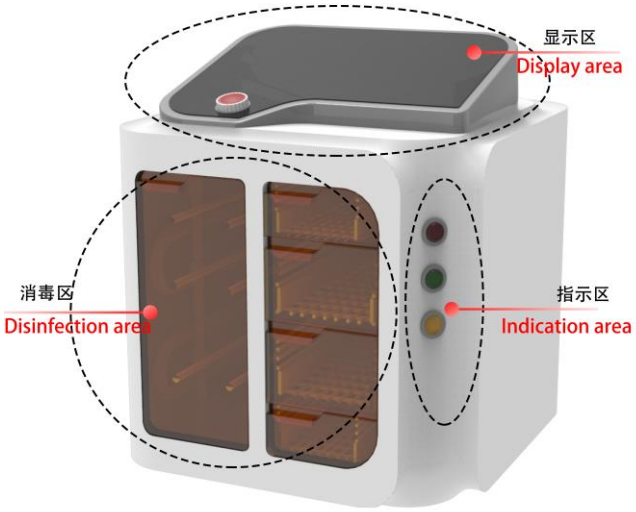

Figure 6. Rendering

4 CONCLUSIONS

In this paper, 24 exclusive engineering parameters are reconstructed according to the design principles of smart home products, and the correlation table between TRIZ standard engineering parameters and smart home product design criteria is constructed to realize the rapid transformation of smart home product design problems into conflicts between TRIZ standard engineering parameters. Through the transformation of the original 40 invention principles of the TRIZ theory, 22 new invention principles of smart home product design and a matrix of smart home product design conflicts were obtained. On this basis, the design process of smart home products based on TRIZ theory is constructed from three stages: analyzing design, solving design requirements, and forming design requirements. Through the design case of a household disinfection machine, it is proved that this method can guide the design of smart home products in a direction, improve the design efficiency, and enrich the design method of smart home products. However, the selection of multiple recommended principles of invention mainly depends on the subjective experience of designers. Therefore, research on the screening criteria for the recommended principles of invention will be carried out in future research.

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