Intelligent Pet Product Design Based on Kansei Engineering Analysis

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Abstract. This paper guides intelligent pet product design by analyzing the needs of the pet-owning population with the research method of Kansei engineering and visualizing the abstract sensual expression into product design elements. Through the design method of Kansei engineering, the intelligent pet product, which has high sensual added value, will have a form and structure that better meets the user's sensual needs. To apply the Kansei engineering approach to clever pet product design, first, the perceptual-cognitive vocabulary of existing pet product users for pet products were obtained through literature research. Then several groups of priority words were screened out through questionnaire surveys. Secondly, several typical and conceptual product samples were selected for analysis to transform the users' vague perceptual imagery into quantifiable and concrete data. Finally, the relevant data structure analysis was conducted by SPSS data analysis software. The analysis results were applied to the elements of product materials, colours, shapes and functions, and a parametric design method was used to design an intelligent pet product. Through the method of Kansei engineering and parametric design, the design of an intelligent pet product is constructed to meet the sensual needs of pet-owning people in the context of the new environment and to provide a reference for the development of similar products.

Keywords: product design · innovative pet products · Kensei engineering · parametric design

1 Introduction

With the development of intelligent control technology and social and economic progress, pet intelligent product design is gradually expanding from a single functional area to a multifunctional use scenario area such as food, housing and play. Pet innovative products as an essential link between the emotions of pets and users, the importance of pet products is self-evident, while this attribute also gives pet products to enhance the emotional experience of users' critical functional needs. Perceptual cognition is an essential indicator for product evaluation and a basis for product planning and decision making. However, due to the ambiguity and uncertainty of perceptual cognition, a scientific method is required to obtain and analyze people's perceptual cognition in the design process and apply it to product design to effectively improve the accuracy of product

positioning and the efficiency of product development. In this paper, we study Kansei engineering, acquire and analyze the perceptual cognition of pet owners, establish the mapping relationship between perceptual intention and intelligent pet product design elements, generate an intelligent pet product design model, and then guide intelligent pet product design to meet the perceptual needs of pet owners better.

2   Research Methodology

2.1   Kansei Engineering

Before consumers buy a particular product, they must have some intention or expectation about the product, such as practical, beautiful, high-grade, sophisticated. The technique of Kansei engineering requires that such intention and feeling be transformed into design elements and applied to develop new products. The principle of Ergonomics is to study the emotional impact of different product features on users by exploring the correlation between product design elements and consumers' perceptual demands to select the best design elements to maximize consumer satisfaction [1]. The specific implementation methods of Kansei engineering vary according to the design requirements, and in Kansei engineering research, Kansei engineering is usually classified according to the implementation methods. Some scholars classify Kansei engineering into qualitative inferential and quantitative inferential according to the inferential method of Kansei engineering, where the former refers to the perceptual discourse classification method and the latter refers to the method that requires a computer, mathematical and statistical analysis support, including Kansei engineering system and Kansei engineering modelling: Other scholars classify Kansei engineering into "tableau method" and "impression method" according to the different methods of perceptual measurement, the former mainly refers to the use of physiological senses of vision, hearing, touch, pain, taste, temperature, smell, body, balance, time [3]. The former is a Kansei engineering technique that uses physiological measurement techniques for visual, auditory, tactile, pain, taste, temperature, smell, body sensation, balance, and time to obtain perceptual information.

This paper focuses on guiding the content of product design practice through a combination of perceptual discourse taxonomy and engineering systems.

This study provides design practices and methods for optimizing pet brilliant product design by organizing user requirements for existing pet products, quantifying them into data structures, and applying research and analysis methods of Kansei engineering to design intelligent pet products.

2.2   Parameterized Design

The parametric design uses the definition of a parametric system to organize the design with a more efficient and profound design method by using relevant computing techniques. This kind of design requires establishing the relationship between design dominant factors and groups in a parametric form. The design dynamics shifts from the dominance of the designer's subjective tendencies to the optimization and generation of objective condition constraints [4].

To carry out a parametric design, the first thing to determine is the core logic of the design. After establishing the basic idea of the design, the designer needs to use parametric design technology to select and set the appropriate parameters according to the design context and design ideas. The main content of the work is to set the constraints through the relevant digital design software, and the design of the standard output between the establishment of the parameter system to generate a computer model can be flexible regulation. The range of parameters set is a variety of information that can be associated with the main contradictions to be solved by design, such as function, structure, cost, climate, etc. This information is converted into a language that the computer can recognize through coding. When the adjustable three-dimensional computer model is completed, the results are expressed through pictorial representation or converted into model data that all disciplines can share. The parameterized relationship here refers to the algorithm, a rule of association between forms. The morphology based on the algorithm is objectively generated because the standard output depends on the formulation of the algorithm and the input data, not on subjective preferences such as personal aesthetics. However, this process does not exclude subjectivity because the formulation of the algorithms and the Selection of the derived results still require the involvement of subjectivity. Parametric modelling based on algorithms makes it possible to quantify the constraints of the design precisely [8].

One of the advantages of parametric design is that the parameters selected in the conceptual design phase and the parameterization relationships set are based on the principle that they can effectively respond to possible changes in subsequent phases. The traditional design approach is to do the conceptual design and then start setting the geometric form.

Once the form is set, it is tough to change it. The basic geometry can only be changed by returning to the initial form control stage. This linear irreversible process of classical design has become increasingly unsuitable for design needs. In contrast, in the parametric design process, even if the initial prototype settings are modified, as long as the logical relationship between parameters and geometry remains unchanged, these updates will be automatically reproduced to the final development stage, the design process, for some reason need to change the original form, with parametric design, it is still easy to return to the original design to modify the scheme. The work after the original design can be updated automatically until the final detail design, which is a fundamental design evolution [7].

This study's optimal design of intelligent pet products is based on the theoretical approach of Kansei engineering and parametric design. The data collected from the design research is analyzed to determine the perceptual intention vocabulary and combined with the parametric design approach to build the pet brilliant product design model; the specific research process is shown in Fig. 1.
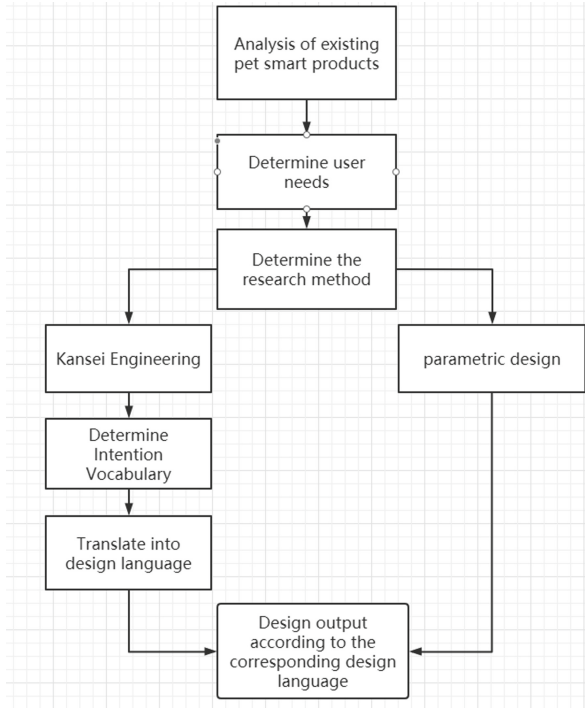
Fig. 1. Study flow

3   Analysis of the Current Situation of Intelligent Pet Products

3.1   The Lack of Emotion Between the User and the Product

Although the development of pet products for feeding and excretion disposal has been rapid in recent years, most of the products on the market only have a single simple function plus an eye-catching shell design and do not pay special attention to the emotional connection between users and pets. Most domestic literature on pet products only studies whether the products meet pets' needs and whether the functions are complete, but there is little mention of the critical emotional interaction between pet owners and their pets.

3.2   Homogenization of Existing Product Functions

Modern companies of all sizes actively seize the pet supplies market, although accelerating the development of intelligent pet supplies, but also inadvertently intensified the problem of product homogenization in the field of intelligent pet supplies. Many brand products are not significantly different in function, lack exploration of the intrinsic value, innovation is not enough, and it is not easy to impress the user.

3.3 The Lack of Security of Existing Products

Safety performance is one of the critical factors affecting the user's choice of innovative pet products, the immaturity of existing products has led to a series of safety problems, such as intelligent water dispenser leakage, smart toys leading to fractures in dogs and cats, which shows that existing products lack of mature research on the design of the underlying structure and material selection.

3.4 The Possibility of Product Technology Upgrade

With the continued development of AI, 5G, the Internet of Things and other technologies, the degree of intelligence of intelligent pet products is also expected to improve further. The development of artificial intelligence and deep learning technology makes the product gradually move from the basic to meet the survival needs of pets to human-machine-pet interaction to meet a deeper level of user psychological value needs.

3.5 Value of Kansei Engineering Research and Analysis of Intelligent Pet Products

The unique feature of designing for pets is the division of the design receptor into two. When designing for pets, the design object is shifted to the pet and the human, with the pet as the direct recipient of the product and the human as the designer, judge and observer taking second place. Thus, meeting pets' needs becomes the essential starting point of pet product design, and good products also regulate human-animal relationships. If the pet product design is seen as the beginning of good communication between people and people, people and pets, then how to grasp a visible physical form to highlight the invisible communication and interaction is a problem that a designer should measure, and the essential thing in the design is to constantly experience the relationship between objects in the process of practice. Pet needs to drive the product's function; the product's practical, cognitive and aesthetic functions are, in a sense, for both the pet and its owner. The practical function is to meet the basic material needs of the pet, while the cognitive and aesthetic functions are to meet the spiritual needs of the owner. After all, product design must be realized through the consumption of the pet owner as a carrier, so the human factor must be incorporated into the design of the product, and the dynamic development of the needs of the pet and its owner has led to the forward development of the relevant product design. In using pet products, the human being is one of the main subjects, and the needs to be met are mainly spiritual needs. This approach is more suitable for pet products.

4   Intelligent Pet Products Design Based on Kansei Engineering

4.1 Principles of Intelligent Pet Product Design

Pet products are different from general commercial products, which are very specific and need to meet not only the needs of pets in their daily lives but also the needs of pet owners to interact with their pets in a series of behavioural and emotional ways,

so they have their own specific needs positioning. In designing intelligent pet products, meeting the daily interaction between pets and pet owners is the most important, so the emotional principle of Kansei engineering design is very important for intelligent pet product design. Secondly, the safety of the product material is also one of the essential principles, and finally, pet products are very targeted and have great uniqueness, so it is essential to design more targeted functions between pets and their owners [2].

4.2 Selection of Representative Samples

This paper collects 30 groups of representative pet products in the current market, unifies the shooting angles and tones of the product pictures, firstly, expert screening, then confirmed by pet industry personnel, and finally finalizes ten pictures of intelligent pet products as the base sample [5].

1) *Group experiments:* The tester invited 20 subjects to conduct an experimental test to compare the similarity of 10 samples one to one and to derive the final scores, which were obtained using a seven-degree scale from 0–7, with 0 being the least similar and seven being very similar. Finally, the mean value of similarity data was derived by computer assistance.
2) *Selection of representative samples:* The processed similarity matrix was imported in spss software, and the samples were analyzed fundamentally by the systematic clustering method. The scale was set to know that the categories were divided into seven categories as the most appropriate classification. Later, by K-means clustering analysis, the categories were also set to five categories, and the number and number of samples in each category, the distance between each sample, and its distance to the center point were obtained. The smaller the distance between the sample and the center of the cluster, the higher the degree of similarity, then the sample is a representative sample.
3) *Determine product perceptual vocabularys:* Relevant perceptual vocabulary was collected and organized through user interviews and research, literature review, and online collection, and the final perceptual intention vocabulary was determined through the following screening methods.
a) Preliminary Selection Identify product requirements based on interviews and surveys: feeding, cleaning excrement, health dynamics monitoring, displaying food water balance, Simple entertainment functions Social attributes. Identify 80 perceptual terms from related functions.
b) Re-selection. After the designer's refined perceptual vocabulary is still not representative, to obtain the natural feel of the target users of intelligent pet products, we must screen the perceptual vocabulary and finally obtain a few words that can represent the overall perceptual imagery of the target users. After analyzing the data, the exact perceptual words were removed, and the most relevant words were selected.

Simple – complex\Extravagant - cheap\Technological - traditional\Smooth - stagnant\Warm - cold\Human - mechanical\Delicate - rough\Intelligent - dull\Heavy - dexterous\Organized - chaotic\Easy to use - difficult to use\Streamlined - geometric\Individual - famous\Functional - decorative\Avant-garde - conservative.

perceptual word pair	sample number				
	1	2	3	4	5
x1	3. 3	2. 55	3. 5	4. 35	4. 3
x2	5. 6	3. 15	4. 6	2. 6	5. 5
x3	4. 1	4. 2	2. 05	4. 8	2. 05
x4	2. 9	2. 5	4. 75	4. 2	4. 7
x5	4. 25	3. 5	1. 7	3. 6	2
x6	5	4. 4	3. 25	2. 8	2. 5
x7	5. 3	2. 8	3. 75	3. 4	5. 6
x8	2. 5	1. 65	5. 05	2. 45	5. 35
x9	4. 8	5. 3	2	2. 8	2. 45
x10	2. 75	1. 85	4. 95	3. 25	5. 25
x11	3. 25	2. 1	3. 05	3. 25	2. 15
x12	4. 9	2. 15	4. 5	2. 4	5. 7
x13	5. 2	4. 2	3. 7	4. 2	4. 3
x14	3. 7	3. 2	2. 35	4. 35	5. 3
x15	4. 35	1. 8	4	3. 9	5

perceptual word pair	sample number				
	6	7	8	9	10
x1	2. 6	3. 2	3. 75	1. 5	4. 3
x2	2. 95	3. 55	2. 45	6. 25	2. 95
x3	5. 35	5. 85	4. 55	4. 35	4. 75
x4	3. 5	3. 1	2. 65	2. 6	3. 35
x5	3. 75	3. 05	2. 9	3. 4	3. 8
x6	4. 5	3. 35	3. 65	3. 5	4. 7
x7	3. 45	4. 65	2. 2	5. 3	2. 75
x8	2. 9	2. 5	3. 5	4	5. 25
x9	2. 25	4. 05	2. 95	5. 45	3. 15
x10	3. 55	2. 8	5. 25	1. 6	4. 2
x11	4. 1	2. 85	3. 7	2. 45	2. 55
x12	4. 95	3. 1	1. 85	3. 5	5. 15
x13	3. 3	4. 35	3. 25	4. 35	3. 9
x14	3. 35	2. 3	5. 55	1. 6	2. 9
x15	4. 15	3. 05	2. 55	5. 95	3. 4

Fig. 2. Product perceptual vocabulary

The 15 pairs of words were numbered as 1–15 in order. Figure 2 shows the mean values of the questionnaire results of the 20 subjects.

4.3 Extraction of Product Design Elements

Different semantic elements were obtained for each typical sample through the semantic analysis of the pet product samples. In order to be able to design the product better, it is necessary to understand further the connection between the product design elements and the semantic elements. A product is composed of many elements, and intelligence components are shape, material, structure, function and colour elements. Each of these elements affects the user's imaginative perception of the purifier. Among the natural sensory elements of the pet product sample, the form of the pet product is the most direct. An analysis of its form concluded that the elements of intelligent pet product design that can directly affect the user's perception are: shell shape and volume.

4.4 Application of the Perceptual Expression of Product Design Imagery Vocabulary

After the above analysis, the core design elements of intelligent pet products have been established. The design-related perceptual imagery vocabulary was also obtained with

	x1	x2	x3	x4	x5	x6	x7
rectangle	+		−		−	−	
cylindrical			−		+		
spherical			+		+		
side smooth			−				
side surface	−		+				+
linestraight − boundary			−		−		
borderline curve		+		+			

	x8	x9	x10	x11	x12	x13	x14	x15
rectangle	−				−			−
cylindrical	+			+				−
spherical		−		+				+
side smooth	−	+					+	−
side surface			+		+			+
linestraight − boundary				+		−		
borderline curve				+				+

Fig. 3. Expressions between perceptual vocabulary and design elements

the sample analysis. In order to guarantee the scientificity of the analysis results, the article uses morphology to decompose each design element step by step [6]. The design elements of the sample pet products were decomposed into planes, surfaces, lines, curves, spheres, circles and squares. The most suitable semantic elements were selected based on the decomposed design elements, and the relationship between the design elements of each part of the intelligent pet product and the imagery semantic vocabulary was further analyzed. The imagery vocabulary was quantified invariantly, and the design elements were analyzed as predicted variables. The relationship values between the imagery vocabulary and each design element were obtained, and the differences in values can reflect the importance of design elements to the semantic vocabulary to different degrees. The degree of influence on the positive words was indicated by the symbol "+" and the degree of influence on the negative words was indicated by the symbol "−" so that the relationship between the degree of processing of each design element and the imagery words could be derived. The relationship between the processing degree of each design element and the imagery vocabulary can be derived, as shown in Fig. 3.

From the table, we can see that the rectangle is conservative, and at the same time, it also has the characteristics of tradition and coldness. The cylindrical shape is relatively conservative, easy to use and traditional. The spherical shape possesses the characteristics of edginess, ease of use, warmth and technology. Side planes have the characteristics of conservative and traditional. Laterally curved shapes have the characteristics of warm and edgy. The intersection line straight line characteristics are traditional, easy to use, and calm. The characteristics of the intersection curve are edgy and smooth while containing the characteristics of streamline. After analyzing the user's perceptual needs for technology, warmth, ease of use, and edginess, the corresponding design elements are spherical, intersection curve, and side surface.

5   Design Practice

Based on the keywords derived from the Kansei engineering research method, which are technological, warm, easy to use, and avant-garde, a series of intelligent pet products were designed, including pet litters, water dispensers, feeders, and toys.

Fig. 4. Nest

5.1 Nest

The design of the nest is mainly parametric construction of the skin, with the periodic round table as the main body, supplemented by wave stripes mounted hollow; the tone is mainly senior gray, and the overall shape looks naive and lovely but does not lose the sense of technology. The top is attached to the dynamic pet monitor, temperature control, automatic sand turning settings and other essential functions. The material is made of resin and synthetic polymer, isolating the internal circuit and making it soft. (Fig. 4).

As shown in Fig. 4, the irregular skin and striped hollow can better attract the pet's attention, the round entrance and exit are convenient for the pet to enter and exit and the display above the entrance and exit allow the owner to grasp the pet's movement in real-time.

5.2 Drinker

The water dispenser has a bubble hollow as the central imagery to increase the sense of nature. Built-in water storage and purification device, automatic temperature adjustment system with the kit, in need of pets need to drink water-soluble drugs on time can be automatically configured (Fig. 5).

As shown in Fig. 5, in the upper part of the water dispenser design, you can directly add drinking water or water-soluble drugs and automatically configure when needed, the bottom of the back end of the spout to increase the oxygen pump to improve the oxygen content of the water and keep the water flowing, dynamic water is more able to attract the attention of pets so that pets do not love to drink water any longer become a problem for the owner to worry about the same time its water purification device also solves the problem of water due to long placement Impurity problem.

5.3 Feeder

The feeder is mainly rounded, and the skin is designed with hexagonal elements, which organically combines the sense of intelligence, streamlining and humanity. On top of

Fig. 5. Drinker

Fig. 6. Feeder

the primary function of regular food feeding, it adds the status of recording the balanced nutrition of pets and can provide timely feedback to the user app (Fig. 6).

As shown in Fig. 6, the separate feeding area solves the problem of conflicting pet meals in multi-pet families. In addition to the regular food drop function, snacks such as freeze-dried and shredded meat can be added to the food storage area, and the owner can set up the APP to put snacks in the meal regularly and quantitatively, enriching the food variety of each meal and making the owner more at ease when going out.

5.4   Cat Ball

The cat ball uses flowers as imagery, extracts the elements of petals and repeats the arrangement to enhance the impression and improve the product's ornamental nature. The material can be directly processed and moulded, simplifying the production steps while increasing the toy's safety.

As shown in Fig. 7, the irregular shape is more attractive to cats, and the round ball shape better fits the criteria of prey selection for cats and improves the interaction between the product and pets. The different volume sizes are designed to take into account the size of pets of different ages and enhance the product's personalization.

Fig. 7. Cat Ball

6   Concluding Remarks

In this paper, the appearance of pet products was studied and analyzed using theoretical knowledge of perceptual engineering and perceptual engineering implementation procedures. The perceptual vocabulary related to innovative pet product products was collected, and the KJ method was used to filter the perceptual vocabulary and build a semantic imagery vocabulary. The semantic analysis method was used to derive the imagery vocabulary for user needs, quantify the user perception, analyze the connection between the perceptual vocabulary and different design elements, and improve the scientific nature of the study. In addition, the appearance design of intelligent pet products was supplemented with a parametric design to make the products more in line with users' perceptual needs. Based on the application of perceptual engineering theory, the form and function of intelligent pet products were improved, and finally, a variety of innovative pet products that meet people's perceptual needs were designed to give users a better experience.

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