Pet Cat Home Design Evaluation System: Based On Grounded Theory-CRITIC-TOPSIS

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***Abstract*—As pet cats assume an increasingly significant role in households, the variety of pet-cat home products on the market has proliferated. However, existing studies primarily focus on qualitative assessments of individual product functions or user experiences, and lack a systematic evaluation framework that combines in-depth exploration of user needs with quantitative analysis. To address this research gap and with the objectives of enhancing user satisfaction and guiding product development, this study constructs a user-needs–based evaluation framework for pet-cat home design. Semi-structured interviews with 12 pet-cat owners were conducted and analyzed via Grounded Theory to elicit four core requirements—Enhancing Pet Life Quality (A1), Ease of Cleaning and Maintenance (A2), Aesthetic Appeal (A3), and Safety and Reliability (A4)—and thirteen primary requirement elements. The CRITIC method was then applied to determine the weights of these dimensions (A1 = 0.30, A2 = 0.28, A3 = 0.27, A4 = 0.16). Four representative market products were selected and ranked using the TOPSIS method based on their proximity to the ideal and negative-ideal solutions, quantitatively evaluating their relative merits. Results indicate that pet owners prioritize Enhancing Pet Life Quality and Ease of Cleaning and Maintenance (combined weight = 0.58), providing focused guidance for designers on spatial layout and material selection. Aesthetic Appeal and Safety and Reliability also remain critical, pointing to specific optimization directions for product appearance and structural integrity. This study not only fills a methodological gap in pet-cat home design evaluation but also offers a practical model for weighting user needs and selecting optimal design solutions, thereby contributing to the standardization and refinement of pet home products.**

***Keywords*—Grounded theory; CRITIC; TOPSIS; design evaluation; pet home**

I. INTRODUCTION

With increasing care for pets among people, the design and development of pet home products have gradually become a highly focused area of attention [1]. Pets are no longer just animals in the household; they are increasingly regarded as family members. With the rising status of pet cats as family members, people are placing greater emphasis on their living space and environment. Kretzler B argues that a good living environment not only enhances the quality of life for pet cats but also improves the interactive experience between pets and their owners [2]. Therefore, providing a home environment that meets pet needs and ensures safety and comfort plays a crucial role in maintaining human-pet relationships and promoting pet happiness. With the increasing importance of pet cat home design, the variety of related products on the market has sharply increased. However, this has also led to varying product quality and a lack of unified evaluation standards and systems. This often leaves consumers confused and uncertain when choosing and purchasing pet cat home products. Therefore, designing suitable pet home products has become a challenging task. To address issues such as pet care due to busy work schedules or short-term trips, FAN JIAXIN has designed a new type of smart pet home based on Internet of Things (IoT) technology [3]. Starting from the challenges encountered in the "human-cat cohabitation" environment in pet-owning households, CHEN XIAOMIN conducted in-depth research on the target audience, generated user personas, and identified the key pain points that the product needs to address most urgently [4]. HAN QIUMING has proposed corresponding design concepts and methods for the design issues of smart pet home products, aiming to provide guidance for pet home product designers [5]. However, the study did not provide a comprehensive, systematic design framework. Xu designed a dual-use household product for both humans and pets based on the concept of maximizing shared living space between pet owners and their pets [6]. Thus, it can be seen that current research primarily focuses on the product improvement process in pet home design, with relatively limited understanding of the development of other pet home products in the market and insufficient research on the evaluation system of pet home design. C. H. Chen pointed out that the design of successful new industrial products is increasingly related to careful market assessment [7]. Design evaluation helps identify and rectify deficiencies and issues in design, thereby enhancing the quality of products, services, or systems [8]. Therefore, it is necessary to develop a scientifically effective evaluation system to guide and promote the progress and development of pet cat home design. By promptly identifying and addressing potential design flaws, it ensures that products meet high standards of quality requirements. Common design evaluation methods used in industrial design include expert reviews, user surveys, and functional testing [9]. Chen conducted data quantification analysis on design evaluation for general products and artificial intelligence products, discussing the significant role of design evaluation in artificial intelligence product development. The study reviewed existing theories and methods, providing a theoretical foundation for constructing a more scientific, objective, and appropriate design evaluation system for artificial intelligence products [10]. Zuo integrates Analytic Hierarchy Process (AHP), Kansei Engineering, Knowledge Engineering, and other theoretical tools to propose a subjective evaluation index system for product design. This approach

summarizes and categorizes user characteristics to better understand users and provide more targeted design services [11]. Wu identified 12 indicators for evaluating humanized packaging design of elderly medications, and proposed a fuzzy comprehensive evaluation method based on expert weighting and its calculation [12]. WANG QIAN summarized the value structure of cultural and creative tourism products based on user and product surveys, and established an evaluation system for the design of cultural and creative products. This provides a reliable theoretical basis for validating the design of cultural and creative products [13]. A robust product evaluation system is essential for the growth of both enterprises and their offerings: it not only enables accurate assessment of product quality and performance, but also facilitates the fulfillment of user needs, enhances competitive advantage, and drives innovation. Although considerable research has been devoted to product design and smart home solutions, systematic analysis of user requirements and the development of an evaluation framework specifically for pet home furnishings remain underexplored. Consequently, despite progress in pet home design, existing appraisal methods in this domain are often subjective and lack scientific rigor, making it difficult for designers and consumers to accurately identify product strengths and weaknesses and thereby impeding further advancement. There is, therefore, an urgent need to establish a scientifically sound evaluation system.

This study seeks to address this gap by proposing a comprehensive, methodologically rigorous evaluation tool tailored to the design of home products for pet cats. It integrates Grounded Theory, the Criteria Importance Through Intercriteria Correlation (CRITIC) method, and the Technique for Order Preference by Similarity to an Ideal Solution (TOPSIS) to form a systematic design–evaluation framework. Methodological innovations of this research are threefold: first, it combines Grounded Theory with quantitative evaluation models to create a structured classification and modeling framework of user needs in pet home design, thereby providing a solid theoretical foundation for product development; second, it employs the CRITIC method for objective weighting, scientifically determining the relative importance of each design element and enhancing the accuracy and impartiality of the indicator system; and third, it constructs an operational TOPSIS-based composite evaluation model, whose feasibility and effectiveness are validated through empirical analysis of representative market products, leading to targeted design optimization recommendations. By introducing this novel evaluation system, the present study fills a critical void in the pet home design literature and offers theoretical guidance for future product improvement and innovation. In practical terms, the framework enables designers and manufacturers to pinpoint deficiencies, refine user experience, and strengthen market competitiveness.

II. Theoretical Research and Analysis

A. Application of Grounded Theory in Design Research

"Grounded Theory" is a research method and methodology in the field of social sciences. This approach, first proposed in 1967 by sociologists Barney Glaser and Anselm Strauss, is a qualitative research method [14]. Grounded Theory emphasizes the original materials obtained from empirical research. It is a methodological approach that involves breaking down collected data, identifying phenomena, conceptualizing these phenomena, and then systematically abstracting concepts to derive categories, thus being a method of discovery [15]. In the research process, Grounded Theory emphasizes extracting concepts and patterns from data rather than applying pre-existing theories [16]. This approach emphasizes discovering issues, phenomena, and relationships from actual observations and data, thereby generating new theories or extending existing ones. The theoretical framework involves not only summarizing data but also understanding the concepts and relationships underlying the research subject. Classic Grounded Theory includes first-level coding (open coding), second-level coding (axial coding), and third-level coding (selective coding) [17]. Open Coding and Axial Coding are two crucial analytical points in Grounded Theory. During the open coding stage, researchers progressively identify and label key concepts based on different contexts and events within the data. Axial coding involves reorganizing and interpreting the data identified during open coding to form a more systematic analytical framework [18]. In various disciplines, Grounded Theory has been widely applied, including its application in the field of design by DENG WEIBIN. To meet children's usage and experiential needs for smart toy houses, DENG WEIBIN proposed a design system strategy based on Grounded Theory and PCA (Principal Component Analysis). Using Grounded Theory's three-level coding, a hierarchical system of design requirements for smart toy houses was developed, providing theoretical insights for toy design [19]. ZHOU RUI used Grounded Theory to analyze in-depth interview data, extracting the core category of "user demand for symbiotic pet furniture", which enhances the potential for designing pet furniture that integrates symbiotic experiences [20]. JIAO YUANYUAN interviewed users using award-winning products from the "IF Design Award" and "Red Dot Design Award". By employing Grounded Theory coding methods, a theoretical model of "product design - product personality - design cues - product imagery" was constructed. This model demonstrates that users' perception of product design is a "product imagery" encompassing subjective ideas and objective objects [21]. CHEN HAOYU, using Grounded Theory as the research method, explored audience demands for museum cultural souvenirs through methods including SET analysis, surveys, and user interviews. Applying Grounded Theory's coding approach, the study uncovered feedback and requirements from the target audience regarding museum cultural souvenirs [22]. JIAO YUANYUAN conducted interviews with users of award-winning products from the "IF Design Award" and "Red Dot Design Award", applying Grounded Theory coding methods. This led to the development of a theoretical model "Product Design - Product Personality - Design Clues - Product Imagery", illustrating that user perception of product design encompasses subjective concepts and objective representations, known as "product imagery" [23]. Mohajan D points out that the purpose of classic Grounded Theory is to theorize and promote understanding of effective knowledge arising from people's lives in society. It is a theory development based on open-ended data [24]. Although Grounded Theory emphasizes theory generation from data,

researchers' subjective judgments and interpretations play a crucial role throughout the research process. Therefore, this study supplements objective theory by integrating CRITIC-TOPSIS. The CRITIC-TOPSIS method provides a systematic and structured evaluation framework, effectively integrating and analyzing theories generated from Grounded Theory, enhancing their practicality and applicability.

B. Application of the CRITIC-TOPSIS Methodology

The CRITIC-TOPSIS method combines the CRITIC method with the TOPSIS method, serving as a multi-criteria decision-making approach commonly used to evaluate and select various alternatives or decisions. The CRITIC method is primarily used for handling multi-criteria decision problems involving qualitative and quantitative criteria. It achieves integration of these two types of criteria by converting them into a common indicator system to determine relative weights of different criteria, thereby considering their importance in multi-criteria decision-making [25]. The TOPSIS method is used to determine the ranking order of alternative solutions or decisions, considering the performance of each solution across all criteria as well as the weights assigned to each criterion. It compares each solution's similarity to an ideal solution and a worst-case scenario, thereby identifying the optimal solution [26]. The combined CRITIC-TOPSIS method first uses the CRITIC method to determine criteria weights, which are then applied in the TOPSIS method to evaluate and rank various solutions. In related research, YANG XIAOHUA employed the CRITIC-TOPSIS evaluation model to analyze the development quality of Chinese listed manufacturing outward foreign direct investment (OFDI) enterprises. The study found that these enterprises have experienced low returns from their overseas investments, with some overseas operations showing negative impacts [27]. QIU BAOLEI utilized a comprehensive evaluation model combining CRITIC and TOPSIS methods to assess the importance of road segments. Subsequently, a case study was conducted on the road network in Wuhan city to validate the model. The results indicated that the top 20% ranked road segments are concentrated on the main arteries of the road network, while lower-ranked segments are primarily located on branch roads [28]. LIU YING used three design proposals for elderly intelligent walking aids as examples. They employed the Analytic Hierarchy Process (CRITIC) to calculate objective weights and further combined these with formulae to calculate composite weights for each criterion. Finally, they used the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to prioritize the design proposals. The evaluation system concluded that functional requirements were the most important criteria in the guidelines for evaluating intelligent elderly assistance products [29]. In conclusion, the CRITIC-TOPSIS method, when combined with subjective and objective weighting approaches in multidimensional data, yields more reasonable comprehensive weight values, demonstrating the specificity and effectiveness of designs or solutions.

C. Modelling the Study

This study develops a rigorous, integrated evaluation framework for pet home design by combining Grounded Theory, the CRITIC method, and TOPSIS, with the aim of providing quantifiable and actionable guidance for design practice. In the qualitative phase, we conducted semi-structured interviews with pet owners and other stakeholders, and applied the three stages of Grounded Theory coding—open coding, axial coding, and selective coding—to iteratively refine the raw textual data. Thirteen primary concepts emerged, which were subsequently grouped into four core dimensions: Comfort, Functionality, Aesthetics, and Safety, thereby yielding a multi-level theoretical model of user needs. In the weighting phase, the CRITIC method was employed to assign objective weights to these four dimensions and their sub-criteria by accounting for both the dispersion of sample ratings and the inter-criterion correlations. Finally, in the ranking phase, representative pet home product designs from the market were evaluated via TOPSIS: after constructing the weighted normalized decision matrix, we identified the positive and negative ideal solutions and computed each alternative's relative distance to these ideals. The resulting closeness coefficients were then used to establish a final ranking of design schemes. This workflow not only closes the loop from user insight to data analysis but also ensures the objectivity and reproducibility of the evaluation results through rigorous quantitative procedures, thus furnishing a practicable decision-support tool for scientific pet home design (see Fig. 1).

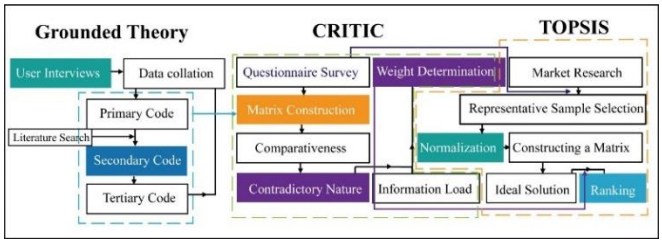

Fig. 1. Research flowchart.

III. Experimental Investigation

A. Data Collection

To capture users' feelings and expectations regarding the use of pet home products, this study employed a semi-structured interview approach. This method was chosen because semi-structured interviews preserve flexibility to a certain extent, allowing respondents to freely express their viewpoints and experiences. This openness facilitates a deeper understanding of user needs [30]. Based on the current research status of pet home products, the interview outline includes basic information about the respondents, their demands and expectations for pet home products, their user experience, and pet behavior. The question design follows the basic principle of starting with easy questions and progressing to more difficult ones, guiding respondents to discuss their overall feelings about using pet home products and then delving deeper into specific usage details and experiences [31]. Due to the widespread geographic distribution of respondents, this study was conducted through online interviews. Before the interviews began, the researchers explained the purpose of the study, the intended use of the data, and the participants' rights and protections, and obtained their informed consent. All participants took part voluntarily and were allowed to withdraw at any stage of the study. A total of 12 users were interviewed from February 2024 to April 2024, as detailed in Table I. Following the qualitative research requirements of

Grounded Theory, each interview session lasted approximately 20-30 minutes and focused on the outlined topics in-depth. Additionally, adhering to the standards of semi-structured interviews, respondents were encouraged to provide descriptions and evaluations beyond the interview outline based on their genuine opinions and experiences [32]. Since Grounded Theory requires theoretical saturation testing, this study employed a concurrent approach of conducting interviews and coding analysis. This involved adding three consecutive interview sessions without obtaining new nodes from existing data as the criterion to conclude interviews. This method is crucial for enhancing the credibility and reliability of qualitative research [33]. This study established nodes based on the research topic and interview results, and conducted further analysis according to the structured model developed.

TABLE I. USER INFORMATION SHEET

Sample Information	Demographic Information	Number of People	Share (%)
Gender	Male	7	58
	Female	5	42
Educational level	High school and below	2	17
	College	2	17
	Undergraduate and above	8	66
Vocational	Student	4	33
	National organization	2	17
	Company Employee	3	25
	Others	3	25
Have you ever purchased a pet home?	Yes	12	100
	No	0	0

B. Open Coding

Open coding is the process of assigning conceptual labels to sentences extracted from raw interview data, followed by categorizing and summarizing these labels into initial conceptual categories [34]. In this study, sentences or segments from 14 interview transcripts were assigned conceptual labels and then categorized and summarized into initial conceptual categories, a process known as initial conceptual categorization. During the coding analysis, all information from the interview data remained open, and effective information was progressively condensed and consolidated through iterative comparisons and content organization. Through open coding of these 12 interview transcripts, a total of 243 free nodes relevant to this study were identified. Subsequently, a subordinate analysis was conducted on these 243 free nodes, integrating and merging original data sentences with similar concepts, resulting in 28 initial categories, as shown in Table II. These initial categories represent direct user demands for pet home products.

TABLE II. OPEN CODING PROCESS

Primary Source Statements	Initial Scope
I wanted the pet bedding to provide enough comfort to keep my pet warm and cosy while resting.	Soft cushioning
Is it possible to include some touch-sensitive design that can trigger some interactive elements when the pet touches it.	Interactive design
Design some shared lounging areas in your home so that your pets can lounge together, brush each other's fur, etc. to enhance their bond.	Peer Interaction
Hopefully, pet homes are modest in terms of the amount of space they take up, so that they can meet your pet's needs without taking up too much space in your home.	Space occupation
We hope that the style of our pet's home will be consistent with the overall style of our home, creating a unified sense of wholeness.	Homogeneity of style
I hope the design can incorporate some level of concealment, allowing pets to have a sense of independent space on it without being disturbed by the external environment.	Private corner
I hope that the pet home can be designed as a shared space so that my pet and I have more opportunities to interact and enjoy family time together.	Human-pet interaction
It's a good idea to offer a selection of different types of toys, as different pets have different preferences.	Fun Toys
It would be nice to have some alternate layouts so that pets can do different kinds of activities on them.	Space for activities
Breathability can help disperse moisture and odours, which is important to keep pet products feeling fresh.	Air ventilation
If you can add some intelligent elements, such as remote monitoring, automatic feeding, etc., it will make the pet home more futuristic.	Nutritional Concerns
	Health Monitoring
Choosing soft and comfortable tones can create a welcoming resting environment for your pet without stimulating their vision.	Colours
	Cosy
I love that Pet Home has some smooth curved designs that make the overall shape look softer and more dynamic.	Shapes and Lines
Hopefully, the production process will focus on craftsmanship and give the pet home a more sophisticated and quality look.	Well-made
	Fine engraving
It is best to consider the size of your pet when designing to ensure that the proportions of your pet home are appropriate for different breeds and sizes of pets.	Proportionality
If it can be easily expanded, modules can be easily added or subtracted as your pet grows or your family's needs change.	Modular design
If there are easily replaceable components, such as mattresses or cushions, they can be easily changed to extend the life of your home.	Separable element
I tend to choose pet homes that use natural materials, such as wood and cotton and linen, which are better for your pet's health.	Harmlessness of materials
The construction of your pet's home must be sturdy and durable enough to withstand biting, chewing and scratching by your pet.	Sturdy construction
	Tough material
The surface should preferably be designed in a way that does not easily hide dirt, making it easy to clean and keep your pet's home tidy.	Smooth surface
It is best to avoid sharp edges and corners when designing to prevent pets from bumping into or injuring themselves while moving around.	No dead space design
Hopefully, the joints of the home will be reinforced to ensure that the overall structure is solid and prevents it from loosening or falling off.	Sturdy connection
	Pressure and impact resistance
For basic pet home products, I might be inclined to go for the more affordable ones.	Cheaply

C. Axial Coding

Axial coding builds upon open coding, aiming to further explore the relationships between conceptual clusters, initial categories, and sub-categories. It involves establishing

connections and logical relationships between initial concepts and sub-categories according to specific rules or pathways [35]. This section involves clustering analysis to establish associations and logical relationships between initial concepts and sub-categories according to specific rules or pathways [36]. Given that the connections between independent categories are not yet clear at this stage, the 28 initial categories derived from open coding were then traced back to interview statements. This analysis aimed to explore the logical relationships between concepts and between concepts and categories [37]. Through refinement, 13 more abstract and representative main categories were identified: Comfortable Living, Entertainment Stimulation, Health Care, Social Interaction, Coordinated Colors, Design Consistency, Aesthetic Shape, Fine Craftsmanship, Removable and Washable Design, Wear and Tear Resistance, Easy Cleaning, Price, and Sturdy Structure. These 13 main categories encompass the initial 28 categories and represent intermediate factors influencing user demands for pet home products, as shown in Table III.

D. Selective Coding

Selective coding, also known as focused coding, is a core component of Grounded Theory. The purpose of this coding is to distill the core categories [38]. Through continuous comparison of the core categories derived from axial coding, the rudimentary framework of theory construction is further demonstrated. Ultimately, four core categories are defined: Enhancing Pet Life, Aesthetic Appeal, Easy Cleaning and Maintenance, and Safety and Reliability. The categories and codes from each level of coding are detailed in Table III. These core categories obtained in this step result from qualitative analysis of the main categories and represent macro factors of user demands [39].

TABLE III. CATEGORIES AND CODES FOR THE THREE LEVELS OF CODING

Core Categories	Main Categories	Initial Categories
Enhance your pet's life A1	Comfortable living B1	Soft cushioning C1
		Ventilation C2
		Private Corner C3
	Entertainment and Stimulation B2	Fun Toys C4
		Interactive design C5
		Activity Space C6
	Health Care B3	Nutritional Concerns C7
		Health Monitoring C8
	Social interaction B4	Peer Interaction C9
		Human and pet interaction C10
Aesthetics A2	Colour coordination B5	Colour Matching C11
		Warmth C12
	Design Consistency B6	Unity of style C13
		Space Occupancy C14
	Aesthetically pleasing shapes B7	Harmonising proportions C15
		Shape and line C16
	Fine craftsmanship B8	Fine Carving C17
		Well-made C18
Easy to clean and maintain A3	Removable and washable design B9	Modular design C19
		Separable Components C20
	Resistant to wear and tear B10	Sturdy Construction C21
		Strong Material C22
		Non-hazardous materialsC23
	Easy to clean B11	Smooth Surface C24
		Dead-end design C25
Safe and reliable A4	Price B12	Cheap C26
	Stable structure B13	Strong connection C27
		Pressure and impact resistant C28

Applying Grounded Theory, an analysis of users yielded core categories, main categories, and initial categories of influencing factors, providing a profound theoretical foundation for the study and preparing for subsequent CRITIC-TOPSIS methodology. The theoretical framework provided by Grounded Theory helps researchers establish the structure of the pet home design evaluation system, including the hierarchy and relationships of concepts, thereby offering an organized evaluation system for CRITIC-TOPSIS methodology.

IV. EXPLORATION OF EXPERIMENTAL EVALUATION OF CRITIC-TOPSIS

In order to obtain representative samples of pet cat home products available in the market, this study employed a systematic sampling method to select products collected from market research. The sampling ensured coverage of different brands, types, and price ranges to comprehensively represent market diversity. The selected products were primarily sourced from Alibaba, a prominent online marketplace, and representative samples are illustrated in Fig. 2. User satisfaction with pet cat home products, identified through user surveys and aligned with main categories derived from Grounded Theory, was assessed using a rating scale of 1 to 5. Ratings ranged from 1 indicating dissatisfaction with the requirement, 3 indicating moderate satisfaction, to 5 indicating high satisfaction. Random distribution of surveys ensured equal opportunity for potential respondents to participate, thereby mitigating selection bias [40]. The survey was distributed randomly, with a total of 384 surveys distributed and 352 valid responses collected. Respondents' ages ranged from 23 to 65 years, with 43% male and 57% female respondents. The survey response rate was 91.7%. Table IV presents the representative products and their average scores obtained from the survey.

Fig. 2. Representative product showcase.

TABLE IV. EVALUATION SCORES FOR EACH REPRESENTATIVE PRODUCT

Samples and Identification Numbers		User Demand Main Categories												
		B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
D1		3	4	3	4	3	2	2	3	4	4	2	4	3
D2		2	5	4	5	2	2	3	3	3	4	1	3	4
D3		4	3	5	4	4	4	5	4	3	2	5	1	5
D4		5	3	4	3	5	4	5	5	1	2	5	2	5

A. Determine User Demand Weights

Firstly, combining the scores obtained from the above questionnaire with the representative samples, a judgment matrix is constructed for each main category. In this study, there are a total of 4 representative samples and 13 indicators, forming a matrix $X = [x_{ij}]m * n$, where x_{ij} represents the value of the j indicator for the i sample.

Data processing: Formula (1) is applied to normalize the initial judgment matrix, and the correlation coefficient matrix is obtained through correlation coefficient calculations, as shown in Table V.

$$X_{ij} = \frac{X_{ij} - Min \le i \le n X_{ij}}{Max \le i \le n X_{ij} - Min X_i \le i \le n X_{ij}} \quad (1)$$

Comparability: Comparability in the CRITIC method is quantified through correlation analysis. It reveals the relative degree of correlation between different criteria, providing a basis for weight allocation [41]. Relevant data is calculated according to Formula (2), where σ_j represents the amount of information in the i upper-level condition.

$$\sigma_j = \sqrt{\frac{\sum_{i=0}^{n}(X_{ij} - X_j)^2}{n-1}} \quad (2)$$

Inconsistency: Indicator conflict examines whether there is any contradiction or conflict between different criteria [42]. If users provide conflicting evaluations between different criteria in pairwise comparisons, it indicates a conflict between these criteria. The relevant values are calculated using Formula (3), as shown in Table VI.

$$S_j = \sum_{j=1}^{m}(1 - r_{ij}) \quad (3)$$

TABLE V. MATRIX NORMALISATION

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
D1	0.33	0.50	0.00	0.50	0.33	0.00	0.00	0.00	1.00	1.00	0.25	1.00	0.00
D2	0.00	1.00	0.50	1.00	0.00	0.00	0.33	0.00	0.67	1.00	0.00	0.67	0.50
D3	0.67	0.00	1.00	0.50	0.67	1.00	1.00	0.50	0.67	0.00	1.00	0.00	1.00
D4	1.00	0.00	0.50	0.00	1.00	1.00	1.00	1.00	0.00	0.00	1.00	0.33	1.00

TABLE VI. CORRELATION COEFFICIENT MATRIX

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
B1	0.00	1.94	0.68	1.95	0.00	0.11	0.23	0.06	1.72	1.89	0.06	1.60	0.33
B2	1.94	0.00	1.43	0.15	1.94	1.90	1.75	1.82	0.52	0.10	1.97	0.33	1.64
B3	0.68	1.43	0.00	1.00	0.68	0.29	0.18	0.57	1.32	1.71	0.41	1.95	0.15
B4	1.95	0.15	1.00	0.00	1.95	1.71	1.54	1.85	0.35	0.29	1.79	0.68	1.43
B5	0.00	1.94	0.68	1.95	0.00	0.11	0.23	0.06	1.72	1.89	0.06	1.60	0.33
B6	0.11	1.90	0.29	1.71	0.11	0.00	0.04	0.10	1.69	2.00	0.02	1.89	0.10
B7	0.23	1.75	0.18	1.54	0.23	0.04	0.00	0.13	1.75	1.96	0.11	1.95	0.01
B8	0.06	1.82	0.57	1.85	0.06	0.10	0.13	0.00	1.90	1.90	0.11	1.67	0.18
B9	1.72	0.52	1.32	0.35	1.72	1.69	1.75	1.90	0.00	0.31	1.61	0.49	1.76
B10	1.89	0.10	1.71	0.29	1.89	2.00	1.96	1.90	0.31	0.00	1.98	0.11	1.90
B11	0.06	1.97	0.41	1.79	0.06	0.02	0.11	0.11	1.61	1.98	0.00	1.81	0.20
B12	1.60	0.33	1.95	0.68	1.60	1.89	1.95	1.67	0.49	0.11	1.81	0.00	1.94
B13	0.33	1.64	0.15	1.43	0.33	0.10	0.01	0.18	1.76	1.90	0.20	1.94	0.00

Information Carrying Capacity: C_j is the information content contained in the i upper-level condition. Higher information content typically implies that users have provided more explicit and consistent comparisons, thereby aiding in determining the relative weights of criteria.

$$C_j = \sigma_j \sum_{i=1}^{m} (1 - r_{ij}) \quad (4)$$

When determining the weights of each category, both the standard deviation of the criteria and the correlation between categories are taken into account. The formula for calculating W_j for the j-th category is as follows:

$$W_j = \frac{C_j}{\sum_{k=1}^{m} C_j} \quad (5)$$

Finally, using CRITIC, weight values for the 13 main categories are calculated. Through the relationship between core categories and main categories, the weight proportions for the four core categories are determined as follows: A1: 0.30, A2: 0.27, A3: 0.28, A4: 0.16, as detailed in Table VII. Utilizing CRITIC for the weighting of main categories in user demands helps ensure that various criteria in the evaluation system accurately reflect the key factors in pet cat home design.

B. Product Evaluation

To provide a more objective evaluation of which of the four representative solutions better aligns with user demands, the TOPSIS research method is employed for design solution evaluation. The primary categories are used to represent the User Satisfaction Decision Index, and a judgment matrix is constructed. In this matrix, columns represent different products, and rows represent different evaluation criteria or attributes, with each element indicating the performance of the corresponding solution on the respective attribute. Subsequently, the judgment matrix is standardized, mapping all data to the same range to ensure consistency in weights between different attributes [43], as shown in Table VIII.

$$Z_{ij} = \frac{X_{ij}}{\sqrt{\sum_{k=1}^{n} (X_{ij})^2}} \quad (6)$$

TABLE VII. VALUES FOR CORE CATEGORY WEIGHTS

	SIGMA	Indicator Conflict	C_j	W_j	SUM	Core Categories
B1	0.43	10.56	4.55	0.061	0.30	A1
B2	0.48	15.48	7.41	0.099		
B3	0.41	10.38	4.24	0.057		
B4	0.41	14.70	6.00	0.080		
B5	0.43	10.56	4.55	0.061	0.27	A2
B6	0.58	9.95	5.74	0.077		
B7	0.50	9.88	4.94	0.066		
B8	0.48	10.36	4.96	0.066		
B9	0.42	15.14	6.35	0.085	0.28	A3
B10	0.58	16.05	9.27	0.124		
B11	0.52	10.14	5.22	0.070		
B12	0.43	16.02	6.90	0.092	0.16	A4
B13	0.48	9.96	4.77	0.064		

TABLE VIII. STANDARDISED MATRIX

	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13
D1	0.41	0.52	0.37	0.49	0.41	0.32	0.25	0.39	0.68	0.63	0.27	0.73	0.35
D2	0.27	0.65	0.49	0.62	0.27	0.32	0.38	0.39	0.51	0.63	0.13	0.55	0.46
D3	0.54	0.39	0.62	0.49	0.54	0.63	0.63	0.52	0.51	0.32	0.67	0.18	0.58
D4	0.68	0.39	0.49	0.37	0.68	0.63	0.63	0.65	0.17	0.32	0.67	0.37	0.58

For the normalized values, the maximum and minimum values are determined to constitute the ideal solution and negative ideal solution. The ideal solution includes the optimum values for each attribute, while the negative ideal value comprises the worst values for each attribute [44]. For each solution, calculate its distance to the ideal solution and the negative ideal solution. The formulas for calculating the distances to the positive and negative ideal solutions are shown in (7) and (8).

$$D_i^+ = \sqrt{\sum_{j=1}^{m} W_j \left(Z_j^+ - Z_{ij}\right)^2} \quad (7)$$

Define the distance of the i evaluation object to the maximum value.

$$D_i^- = \sqrt{\sum_{j=1}^{m} W_j \left(Z_j^- - Z_{ij}\right)^2} \quad (8)$$

Define the distance of the i evaluation object to the minimum value.

Based on the distance between representative solutions and the ideal solution, calculate the comprehensive evaluation index for each solution. Here, W_j incorporates the weight values of each main category obtained through CRITIC. Calculate the D^+ and D^- values for the three solutions, determine their comprehensive scores, and rank them, as shown in Table IX.

$$C_i = \frac{D_i^-}{D_i^+ + D_i^-} \quad (9)$$

TABLE IX. COMPREHENSIVE PROGRAMME RANKING

	D+	D-	CI	Ranking
D1	0.227396	0.261169	0.534564	1
D2	0.253126	0.220596	0.465665	4
D3	0.231772	0.255408	0.524258	2
D4	0.242646	0.263505	0.520606	3

V. Discussion and Analysis

This study applied Grounded Theory to explore user demands for cat furniture, identifying four primary core categories. The CRITIC method assisted in determining the weights of these core categories, quantifying the importance users place on different needs. According to the research findings, enhancing pet living scored highest at 30% weightage, followed by ease of cleaning and maintenance at 28%, aesthetic appeal at 27%, and safety and reliability at 16%. These weights reflect users' prioritization factors when selecting cat furniture, emphasizing how products can meet expectations by offering more comfortable and easier maintenance experiences. The TOPSIS method, through comprehensive scoring, ranked and prioritized relevant pet furniture products in the market, aiding researchers in understanding which products best align with user needs and guiding future product improvements. Therefore, based on this study's findings, recommendations for enhancing current cat furniture products will be provided.

The core categories for enhancing pet life include four main areas: comfortable living, entertainment stimulation, health care, and social interaction. Among these, entertainment stimulation and social interaction hold the highest importance in user evaluations, as users primarily assess from their own perspectives, indicating a desire for these interactive elements from their pets. Therefore, in the design of pet furniture products, activities for pets are crucial. Setting up activity areas where cats can exercise and incorporating toys that stimulate their hunting instincts, such as climbing frames and rolling balls, are essential. Product D1 received high satisfaction ratings partly due to providing excellent entertainment for pets. It features multiple platforms and shelves of varying heights, allowing cats to rest and observe their surroundings at different levels. Good air circulation promotes pet health, and D1's fully open design further demonstrates its attention to pets' living environment. Users seek emotional relief through interacting with their pets, and positive human-animal interactions help build stronger bonds between pets and owners [45]. In terms of social interaction, Mondémé C's research points out that pet cats are social animals that require interaction and communication with humans and other animals, which is crucial for their psychological well-being [46]. Therefore, a good social environment can help cats expend energy, release stress, and prevent these issues from arising. Therefore, in the product development process, various social elements can be introduced, such as beds of different sizes, bedding, or pet accessories, which can attract cats to gather around them, promoting interaction and play among them [47]. In related research, Cai S proposed an emotional human-machine interface design method for a mobile app. Testing has shown that it can help cat owners flexibly control the litter box, thereby enhancing the comfort and safety of cats [48]. Based on this research, designers can develop more toys equipped with sensors and responsive features, such as touch-sensitive, sound-sensitive, or motion-sensitive capabilities, to interact based on the cat's actions or sounds. He H believes that adding interactive functionalities requires a systematic analysis from the perspectives of humans, environment, and pets, thereby providing solutions to enhance interaction between humans and pets [49]. From a human perspective, it is necessary to develop products that cater to different age groups and abilities. From an environmental perspective, interactive products should be integrated sensibly into home design, ensuring they do not occupy excessive space while meeting pets' needs adequately. From a pet perspective, designs should stimulate natural behaviors and habits.

The primary category for easy cleaning and maintenance is divided into three parts: detachable and washable design, durable and chew-resistant, and easy to clean, with durability and chew resistance being the highest proportion. This is because cats naturally enjoy scratching and biting objects as part of their clawing and displaying behaviors [50]. Therefore, designing products with good durability and chew resistance can effectively reduce the likelihood of other furniture or items being damaged. This requires selecting high-strength materials during the product design phase that can withstand pets' chewing and scratching behaviors, such as high-density fiberboard (HDF), high-strength polymers, hard rubber, and others [51]. L. da Silva Gonçalves also pointed out in their research that pet cats exhibit extremely high levels of activity [52], therefore, the product surface should be designed with non-slip or textured features to increase stability and safety for pets during use. Secondly, the core requirement of aesthetic appeal is divided into four aspects: coordinated colors, design consistency, aesthetic shapes, and refined craftsmanship. Among these, design consistency scores the highest, while the scores for other requirements are equal. Design consistency refers to the overall uniformity of the appearance of the entire pet home product, including the consistency of design elements such as color, material, and shape, ensuring a harmonious and unified overall look. Cross N's research indicates that consistent design enhances the overall aesthetic and quality perception of products. Through unified design language and style, products appear more coordinated and professional, thereby enhancing consumer desire to purchase and satisfaction [53]. Designers should establish a theme or core concept based on the product's use scenarios and functionalities to ensure consistency in the overall shape and contours, avoiding abrupt or discordant visual effects. Attention to detail in product design, such as edge treatments and decorative elements, is crucial to seamlessly integrate each detail into the overall design without appearing abrupt or incongruous. Considering cats' perception of colors and ensuring alignment with owners' aesthetic preferences, selecting pet products that harmonize with home décor colors ensures coherence with the overall interior design and color scheme. This approach guarantees consistency between pet users and home aesthetics, creating a harmonious and unified indoor environment [54]. In the final core category, safety and reliability, it includes product pricing and sturdy structure. Market research has shown significant price variations in pet home products, prompting users to find a balance between quality and price. Businesses should offer economical and high-end options to cater to diverse user needs and budgets [55]. Pet homes should also include additional supports or fixing devices to enhance the structural stability.

This study has successfully established a comprehensive evaluation system aimed at assessing and optimizing the quality of pet cat home designs. By applying this evaluation

system, the strengths and weaknesses of various design proposals across different evaluation criteria can be clearly identified, providing scientific decision-making support for designers and decision-makers. Furthermore, this evaluation system not only focuses on the performance of individual design proposals but also offers flexible application in diverse scenarios and environments, enhancing its utility and applicability. Future research can delve deeper into exploring the interaction patterns and behavioral needs between pet cats and humans to further enhance the accuracy and practicality of the evaluation system. Through interdisciplinary collaboration integrating expertise from animal behavior, psychology, and design fields, a more comprehensive and in-depth assessment framework can be developed to drive innovation and development in pet cat home design. In conclusion, this study provides robust methods and tools for understanding and improving pet cat home design. Future research will continue to explore and optimize the evaluation system, fostering ongoing progress and innovation in this field.

VI. Conclusion

This study developed a comprehensive evaluation framework for pet-cat home design to address two pervasive issues in current pet furniture development: the inadequate consideration of user needs and the lack of clear design standards. By employing Grounded Theory for qualitative requirement elicitation and integrating CRITIC and VIKOR for quantitative analysis, the framework systematically identifies and assesses key design criteria. These criteria are organized into four primary dimensions—Enhancing Pet Life Quality, Ease of Cleaning and Maintenance, Aesthetic Appeal, and Safety—each of which is further subdivided into thirteen specific sub-dimensions. Compared with traditional evaluation methods that often rely solely on subjective judgments, our multidimensional framework overcomes the limitations of single-method approaches by providing a holistic analysis of design requirements and offering precise, data-driven guidance for design decision-making. Despite the practical utility of the proposed framework and its theoretical contributions to pet-cat furniture design, several limitations remain. First, as smart technologies become more prevalent in the market, future studies should explore how features such as intelligent monitoring and automated cleaning can be seamlessly integrated into traditional designs to enhance both functionality and user experience. Second, while this research focused primarily on the needs of the pet, it did not fully examine the dynamics of owner–pet interaction. Subsequent investigations should therefore investigate owners' expectations for furniture design and how their usage behaviors influence product development, particularly in terms of spatial utilization and aesthetic coherence.

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